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POISONS

EIR EFFECTS AND DETECTION

A MANUAL FOR THE USE OF ANALYTICAL
CHEMISTS AND EXPERTS

*H AN INTRODUCTORY ESSAY ON THE GROWTH OF MODERN
TOXICOLOGY*

BY

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With Tables and Illustrations

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POISONS

THEIR EFFECTS AND DETECTION.

VI. THE MYDRIATIC GROUP OF ALKALOIDS—ATROPINE—HYOSCYAMINE—SOLANINE—CYTISINE.

I. ATROPINE.

Atropine (*Daturine*), $C_{17}H_{23}NO_3$.—This important alkaloid has been found in all parts of the *Atropa belladonna*, or deadly nightshade, and in all the species of *Datura.*

The *Atropa Belladonna* is indigenous, and may be found in some parts of England, although it cannot be said to be very common. It belongs to the *Solanaceæ*, and is a herbaceous plant with broadly ovate entire leaves, and lurid-purple axillary flowers on short stalks; the berries are violet-black, and the whole of the plant is highly poisonous. The juice of the leaves stain paper a purple colour. The seeds are very small, kidney-shaped, weighing about 90 to the grain; they are covered closely with small, round projections, and are easily identified by an expert, who may be supposed to have at hand (as is most essential) samples of different poisonous seeds for comparison. The nightshade owes its poisonous properties to *atropine.*

The yield of the different parts of belladonna, according to Gunther,[*] is as follows:[†]

Atropine appears to exist in the plant in combination with malic acid. According to a research by Ladenburg, hyoscyamine is associated with atropine, both in the Belladonna and Datura plants.[‡]

The Datura Stramonium or Thorn-Apple is also indigenous in the British Islands, but like belladonna, it cannot be considered a common plant. Datura belongs to the Solanaceæ; it grows from one to two feet

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[*] *Pharm. Zeitschr. f. Russl.*, Feb., 1869. Dragendorff, "*Die Chemische Werthbestimmung einiger Starkwirkenden Droguen.*" St. Petersburg, 1874.

[†] See table XV., p. 336.

[‡] *Ber. d. Deutsch. Chem. Ges.*, Bd. 13.

TABLE XV.—*BELLADONNA*—ALKALOIDAL CONTENT OF VARIOUS PARTS OF THE PLANT.

	Quantity of Alkaloids in the Fresh substance, per cent.		Quantity of Alkaloids in the Dry Substance, per cent.	
	(*a.*) By Weighing.	(*b.*) By Titration.	(*a.*) By Weighing.	(*b.*) By Titration.
Leaves, . .	0·2022	0·20072	0·838	0·828
Stalk, . .	0·0422	....	0·146	....
Ripe fruit, . .	0·2128	0·20258	0·821	0·805
Seed, . .	0·26676	....	0·407	....
Unripe fruit, .	0·1870	0·1930	0·955	0·955
Root, . .	0·0792	....	0·210	....

in height, and is found in waste places. The leaves are smooth, the flowers white; the fruit is densely spinous (hence the name thorn-apple), and is divided into four dissepiments below, two at the top, and containing many seeds.

The *Datura,* or the *Dhatura*-plants, of India, have in that country a great toxicological significance, the white-flowered datura, or *Datura alba,* growing plentifully in waste places, especially about Madras. The purple-coloured variety, or *Datura fastuosa,* is also common in certain parts. There is a third variety, the *Datura atrox,* found about the coast of Malabar. The seeds of the white datura have been mistaken in India for those of capsicum. The following are some of the most marked differences:—

SEEDS OF THE COMMON OR WHITE DATURA.	SEEDS OF CAPSICUM.
(1.) Outline angular.	Outline rounded.
(2.) Attached to the placenta by a large, white, fleshy mass separating easily, leaving a deep furrow along half the length of the seed's concave border.	Attached to the placenta by a cord from a prominence on the concave border of the seed.
(3.) Surface scabrous, almost reticulate, except on the two compressed sides, where it has become	Uniformly scabrous, the sides being equally rough with the borders.

almost glaucous from pressure of the neighbouring seeds.	
(4.) Convex border thick and bulged, with a longitudinal depression between the bulgings, caused by the compression of the two sides.	Convex border thickened, but uniformly rounded.
(5.) A suitable section shows the embryo curved and twisted in the fleshy albumen.	The embryo, exposed by a suitable section, is seen to resemble in outline very closely the figure 6.
(6.) The taste of the datura seeds is very feebly bitter. The watery decoction causes dilatation of the pupil.	The taste of capsicum is pungent; a decoction irritates the eye much, but does not cause dilatation of the pupil.

The identity of the active principle in both the datura and belladonna tribes is now completely established.*

Pharmaceutical Preparations—(*a.*) *Belladonna.*—The various pharmaceutical preparations are:—The leaves, root, extract of the leaves, an ointment and a plaster made with the extract, a tincture of the leaves, a liniment (which is practically a tincture of the root, flavoured with camphor), atropine itself, a weak alcoholic solution of atropine (·83 per cent.), an ointment of atropine (1·66 per cent.), the sulphate of atropine, and, lastly, a solution of sulphate of atropine (·83 per cent.)

(*b.*) *Stramonium.*—An extract of the seeds is officinal in Britain, On the Continent there is an *Extractum cum dextrino.* In the former 1·621 to 1·88 per cent. of atropine has been found; in the latter ·9 per cent. The alkaloidal content of the seeds varies extremely; hence, extracts of the seeds must likewise vary. The B.P. Tincture of Stramonium is made by exhausting 2½ oz. of stramonium seeds by 20 fl. ozs. of proof spirit. Stahl found in Tincture of Stramonium ·066 per cent.; Mayer, ·063 per cent., of atropine. (*Dragendorff.*)

It would appear that most of the pharmaceutical preparations can be titrated by adding Mayer's reagent (diluted one-half) to an acid aqueous solution of the active principle, each cc. being equal to 6·25 mgrms. of atropine, when a solution of the approximate strength of 1 : 500 is operated upon. Or the alkaloid may be precipitated by the undiluted Mayer's reagent, the precipitate collected on a filter, washed with water, and dissolved in alcohol of 90 to 95 per cent. The alcoholic solution is then evaporated and the residue weighed: it contains 44·9 per cent. of atropine.*

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* See a recent research by Ernst Schmidt, *Ueber die Alkaloide der Belladonna-Wurzel u. des Stechapfel-Samens. Lieb. Annl.*, Bd. 208, 1881.

Properties of Atropine.—Atropine ($C_{17}H_{23}NO_3$) forms colourless crystals (mostly in groups or tufts of needles and prisms), which are heavier than water, and possess no smell, but an unpleasant, long-enduring, bitter taste. The experiments of E. Schmidt place the melting point between 115° and 115·5°. It is said to sublime scantily in a crystalline form, but the writer has been unable to obtain any crystals by sublimation; faint mists collect on the upper disc, at about 123°, but they are perfectly amorphous.

Its reaction is alkaline; one part requires, of cold water, 300; of boiling, 58; of ether, 30; of benzene, 40; and of chloroform, 3 parts for solution. In alcohol and amyl alcohol it dissolves in almost every proportion. It turns the plane of polarisation weakly to the left.

Atropine mixed with nitric acid exhibits no change of colour. The same is the case with concentrated sulphuric acid in the cold; but on heating, there ensues the common browning, with development of a peculiar odour, likened by Gulielmo to orange flowers, to Dragendorff to the flowers of the *Prunus padus*, and by Otto to the *Spiræa ulmaria*—a sufficient evidence of the untrustworthiness of this as a distinctive test. The odour, indeed, with small quantities, is certainly not powerful, nor is it strongly suggestive of any of the plants mentioned. A far more intense odour is given off if a speck of atropine is evaporated to dryness with a few drops of strong solution of baryta, and heated strongly; the scent is decidedly analogous to that of hawthorn-blossom, and unmistakably agreeable.

By the action of fuming hydrochloric acid, or that of caustic alkalies, atropine is decomposed into tropine ($C_8H_{15}NO$) and tropic acid ($C_9H_{10}O_3$)† Tropine is a white crystalline, strongly alkaline mass, melting at 60°, and volatilising at 230° undecomposed. It is soluble in water, alcohol and ether, and gives precipitates with tannic acid, iodised hydriodic acid, Mayer's reagent, gold chloride, and mercuric chloride. Tropine gold chloride melts at 210° to 212°. Atropic acid ($C_9H_8O_2$), melting point 198° to 200°, and isatropic acid ($C_9H_8O_2$), may also be obtained by the action of hydrochloric acid—the first in radiating crystals, melting at 106°, and capable of distillation; the second, in thin rhombic plates, melting about 200°, and not volatile. Carbazotic acid also gives a precipitate of beautiful plates. To obtain this the carbazotic acid must be in excess, and time must be given for the precipitate to form.

A solution of iodine in potassic iodide gives a precipitate in a dilution of even 1 : 10000. The precipitate which atropine gives with chloride of gold

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*Dragendorff, *Op. cit.*

†The reaction may be represented thus—$C_{17}H_{23}NO+_{3}H_2O=C_8H_{15}NO+C_9H_{10}O_3$.

is in the form of rosettes, or needles; its composition is $C_{17}H_{23}NO_3HCl+AuCl_3$; melting point, 136° to 138°. On heating it in water, the crystals change to oily masses. If platinum chloride is added to atropine, there is no immediate precipitate, but, after long standing, monoclinic crystals of a platinum compound form: they have the composition $(C_{17}H_{23}NO_3,HCl)_2+PtCl_4$.*

Such are the chief chemical characteristics of the pure substance, but the analyst separates minute quantities of atropine from the tissues of the body in an amorphous form, and he will find it difficult to obtain any crystalline compound whatever.

Tests.—According to Vidali, if atropine, or one of its salts, is covered with a little fuming nitric acid, dried up on the water-bath, and when cold moistened with a drop of potassa dissolved in absolute alcohol, a violet colour is instantly produced, and soon passes into a fine red. Only the violet colour is characteristic, as strychnine also gives a beautiful red colour if similarly treated. According to the author, 0·000001 grm. of atropine sulphate can thus be detected. None of the other important alkaloids give a similar reaction.

The most reliable test is the physiological action on the pupil of the eye, a solution of atropine, even when so weak as 1 : 130000, dilating the iris. This action on the iris has been studied by Ruyter,† Donders, and Von Graefe.‡ It is entirely a local action, taking its effect when in dilute solution, only on the eye to which it has been applied; and it has been produced on the eyes of frogs, not only in the living subject, but after the head has been severed from the body and deprived of brain. The thinner the cornea the quicker the dilatation; therefore, the younger the person or animal, the more suitable for experiment. In frogs, with a solution of 1 : 250, dilatation commences in about five minutes; in pigeons, seven minutes; and in rabbits, ten minutes. In man, a solution of 1 : 120 commences to act in about six to seven minutes, reaches its highest point in from ten to fifteen minutes, and persists more or less for six or eight days. A solution of 1 : 480 acts first in fifteen to twenty minutes, and reaches its greatest point in twenty minutes; a solution of 1 : 48000 requires from three-quarters of an hour to an hour to show its effect. Dogs and cats are far more sensible to its influence than man, and therefore more suitable for experiment. If the expert chooses, he may essay the proof upon himself, controlling the dilatation by Calabar bean; but it is seldom necessary or advisable to make personal trials of this nature.[*]

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* Careful measurements of the angles of the crystals of the platinum compound are to be found in Schmidt's paper.—*Op. cit.*

† *De Actione Atropæ Belladonnæ in Iridem. Traj. ad Rhen.*, 1852.

‡ Von Graefe. *Arch. Opthal.*, ix., 262, 1864.

Statistics of Atropine Poisoning.—Since atropine is the active principle of belladonna and datura plants, and every portion of these—root, seeds, leaves, and fruit—has caused toxic symptoms, poisoning by any part of these plants, or by their pharmaceutical or other preparations, may be considered with strict propriety as atropine poisoning. Our English death statistics for the five years ending 1880, record 37 deaths (23 males and 14 females) from atropine (for the most part registered under the head of belladonna); 8 (or 21·6 per cent.) were suicidal, the rest accidental.

The greatest number of the accidental cases arise from mistakes in pharmacy; thus, belladonna leaves have been supplied for ash-leaves; the extract of belladonna has been given instead of extract of juniper; the alkaloid itself has been dispensed in mistake for theine:[†] a more curious and marvellously stupid mistake is one in which it was dispensed instead of assafœtida (Schauenstein, *Op. cit,* p. 652). Further, valerianate of atropine has been accidentally substituted for quinine valerianate, and Schauenstein relates a case in which atropine sulphate was administered subcutaneously instead of morphine sulphate; but the result was not lethal. Many other instances might be cited. The extended use of atropine as an external application to the eye naturally gives rise to a few direct and indirect accidents. Serious symptoms have arisen from the solution reaching the pharynx through the lachrymal duct and nose. A curious indirect poisoning, caused by the use of atropine as a collyrium, is related by Schauenstein.[‡] A person suffered from all the symptoms of atropine poisoning; but the channel by which it had obtained access to the system was a great mystery, until it was traced to some coffee, and it was then found that the cook had strained this coffee through a certain piece of linen, which had been used months before, soaked in atropine solution, as a collyrium, and had been cast aside as of no value.

Accidental and Criminal Poisoning by Atropine.—External applications of atropine are rapidly absorbed—*e.g.*, if the foot of a rat be steeped for a little while in a solution of the alkaloid, and the eyes watched, dilatation of the pupils will soon be observed. If the skin is broken, enough may be absorbed to cause death. A case is on record in which ·21 grm. of atropine sulphate, applied as an ointment to the abraded skin, was fatal.* Atropine has also been absorbed from the bowel; in one case, a clyster containing the active principles of 5·2 grms. (80 grains) of belladonna root was administered to a woman twenty-seven years of age, and caused death. Allowing the root to have been carefully dried, and to contain ·21 per cent. of alkaloid, it would seem that so little as 10·9 mgrms. (·16 grain) may even prove fatal, if left in contact with the intestinal mucous membrane. Belladonna berries and stramonium leaves and seeds are eaten occasionally by children. A remarkable series of poisonings by belladonna berries occurred in London during the autumn of 1846.

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[*] A. Ladenburg (*Compt. Rend.*, 90, 92), having succeeded in reproducing atropine by heating tropine and tropic acid with hydrochloric acid, by substituting various organic acids for the tropic acid, has obtained a whole series of compounds to which he has given the name of *tropeines*. One of these, hydroxytolnol (amygdalic) tropeine, he has named *homatropine*. It dilates the pupil, but is less poisonous than atropine.

[†] Hohl, *De Effectu Atropini. Diss. Halle,* 1863.

[‡] Maschka's *Handbuch.*

Criminal poisoning by atropine in any form is of excessive rarity in Europe and America, but in India it has been frightfully prevalent. In all the Asiatic cases the substance used has been one of the various species of datura, and mostly the bruised or ground seeds, or a decoction of the seeds. In 120 cases recorded in papers and works on Indian toxicology, I find no less than 63 per cent. of the cases criminal, 19 per cent. suicidal, and 18 per cent. accidental. In noting these figures, however, it must be borne in mind that known criminal cases are more certain to be recorded than any other cases. The drug has been known under the Sanscrit name of *dhatoora* by the Hindoos from most remote times. It was largely used by the Thugs, either for the purpose of stupifying their victim or for killing him; by loose wives to ensure for a time the fatuity of their husbands; and, lastly, it seems in Indian history to have played the peculiar *rôle* of a state agent, and to have been used to induce the idiocy or insanity of persons of high rank, whose mental integrity was considered dangerous by the despot in power. The Hindoos, by centuries of practice, have attained such dexterity in the use of the "datura" as to raise that kind of poisoning to an art, so that Dr. Chevers, in his "Medical Jurisprudence for India," † declares that "there appears to be no drug known in the present day which represents in its effects so close an approach to the system of slow poisoning, believed by many to have been practised in the Middle Ages, as does the datura."

Fatal Dose.—It is impossible to state with precision the exact quantity which may cause death, atropine being one of those substances whose effect, varying in different cases, seems to depend on special constitutional tendencies or idiosyncracies of the individual. Some persons take a comparatively large amount with impunity, while others scarcely bear a very moderate dose without exhibiting unpleasant symptoms. Eight mgrms. (⅛ grain) have been known to produce poisonous symptoms, and ·129 grm. (2 grains) death. We may therefore infer that about ·0648 grm. (1 grain) would, unchecked by remedies, probably act fatally; but very large doses have been recovered from, especially when treatment has been prompt.

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* Ploss, *Zeitschr. f. Chir.*, 1863.

† Dr. Chevers' work contains a very good history of datura criminal poisoning.

Atropine is used in veterinary practice, from 32·4 to 64·5 mgrms. (½ to 1 grain) and more being administered subcutaneously to horses; but the extent to which this may be done with safety is not yet established.

Action on Animals.—The action of atropine has been studied on certain beetles, on reptiles (such as the salamander, triton, frogs, and others), on guinea pigs, hedgehogs, rats, rabbits, fowls, pigeons, dogs, and cats. Among the mammalia there is no essential difference in the symptoms, but great variation in the relative sensibility; man seems the most sensitive of all, next to man come the carnivora, while the herbivora, and especially the rodents, offer a considerable resistance. According to Falck the lethal dose for a rabbit is at least ·79 mgrm. per kilo. It is the general opinion that rabbits may eat sufficient of the belladonna plant to render their flesh poisonous, and yet the animals themselves may show no disturbance in health; but this must not be considered adequately established. Speaking very generally, the higher the animal organization, the greater the sensibility to atropine. Frogs are affected in a peculiar manner. According to the researches of Fraser,* the animal is first paralysed, and some hours after the administration of the poison lies motionless, the only signs of life being the existence of a slight movement of the heart and muscular irritability. After a period of from forty-eight to seventy-two hours, the fore limbs are seized with tetanic spasms, which develop into a strychnine-like tetanus.

Action on Man.—When atropine is injected subcutaneously, the symptoms, as is usually the case with drugs administered in this manner, may come on immediately, the pupil not unfrequently dilating almost before the injection is finished. This is in no way surprising; but there are instances in which decoctions of datura seeds have been administered by the stomach, and the commencement of symptoms has been as rapid as in poisoning by oxalic or even prussic acid. In a case tried in India, in July, 1852, the prosecutor declared that while a person was handing him a *lota* of water, the prisoner snatched it away on pretence of freeing the water from dirt or straws, and then gave it to him. He then drank only two mouthfuls, and complaining of the bitter taste, fell down insensible within forty yards of the spot where he had drunk, and did not recover his senses until the third day after. In another case, a man was struck down so suddenly that his feet were scalded by some hot water which he was carrying. (*Chevers*).

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* *Transact. of Edin. Roy. Soc.*, vol. xxv., p. 449. *Journ. of Ant. and Physiol.*, May, 1869, p. 357.

When the seeds, leaves, or fruit of atropine-holding plants are eaten, there is, however, a very appreciable period before the symptoms commence, and, as in the case of opium poisoning, no very definite rule can be laid down, but usually the effects are experienced within half an hour. The first sensation is dryness of the mouth and throat; this continues increasing, and may rise to such a degree that the swallowing of liquids is an impossibility. The difficulty in swallowing does not seem to be entirely dependent on the dry state of the throat, but is also due to a spasmodic contraction of the pharyngeal muscles. Tissore* found in one case such constriction that he could only introduce emetics by passing a catheter of small diameter. The mucous membrane is reddened, and the voice hoarse. The inability to swallow, and the changed voice, bear some little resemblance to hydrophobia—a resemblance heightened to the popular mind by an inclination to bite, which seems to have been occasionally observed; the pupils are early dilated, and the dilatation may be marked and extreme; the vision is deranged, letters and figures often appear duplicated; the eyeballs are occasionally remarkably prominent, and generally congested; the skin is dry, even very small quantities of atropine arresting the cutaneous secretion: in this respect atropine and pilocarpine are perfect examples of antagonism. With the dryness of skin, in a large percentage of cases, occurs a scarlet rash over most of the body. This is generally the case after large doses, but Stadler saw the rash produced on a child three months old by ·3 mgrm. of atropine sulphate. It appeared three minutes after the dose, lasted five hours, and was reproduced by a renewed dose.† The temperature of the body with large doses is raised; with small, somewhat lowered. The pulse is increased in frequency; and is always above 100—mostly from 115 to 120, or even 150 in the minute. The breathing is at first a little slowed, and then very rapid. Vomiting is not common; the sphincters may be paralysed so that the evacuations are involuntary, and there may be also spasmodic contractions of the urinary bladder. The nervous system is profoundly affected; in one case there were clonic spasms,‡ in another,§ such muscular rigidity, that

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[*] Gaz. hebd., 1856.

† *Med. Times.*, 1868.

‡ *Lancet*, vol. i., 1881, 414.

§ *Ibid.*, vol. i., 1876, p. 346.

the patient could with difficulty be placed on a chair. The lower extremities are often partly paralysed, there is a want of coördination, the person reels like a drunken man, or there may be general jactitation. The disturbance of the brain functions is very marked; in about 4 per cent. only of the recorded cases, has there been no delirium or very little—in the majority delirium is present. In adults this generally takes a garrulous, pleasing form, but every variety has been witnessed. Dr. H. Giraud describes the delirium from datura (which it may be necessary to again repeat is *atropine* delirium), as follows:—"He either vociferates loudly or is garrulous, and talks incoherently; sometimes he is mirthful, and laughs wildly, or is sad and moans, as if in great distress; generally he is observed to be very timid, and, when most troublesome and unruly, can always be cowed by an angry word, frequently putting up his hands in a supplicating posture. When approached he suddenly shrinks back as if apprehensive of being struck, and frequently he moves about as if to avoid spectra. But the most invariable accompaniment of the final stage of delirium, and frequently also that of *sopor*, is in the incessant picking at real or imaginary objects. At one time the patient seizes hold of parts of his clothes or bedding, pulls at his fingers and toes, takes up dirt and stones from the ground, or as often snatches at imaginary objects in the air, on his body or anything near him. Very frequently he appears as if amusing himself by drawing out imaginary threads from the ends of his fingers, and occasionally his antics are so varied and ridiculous, that I have seen his near relatives, although apprehensive of danger, unable to restrain their laughter." * This active delirium passes into a somnolent state with muttering, catching at the bed-clothes, or at floating spectra, and in fatal cases the patient dies in this stage. As a rule, the sleep is not like opium coma; there is complete insensibility in both, but in the one the sleep is deep, without muttering, in the other, from atropine, it is more like the stupor of a fever. The course in fatal cases is rapid, death generally taking place within six hours. If a person live over seven or eight hours, he usually recovers, however serious the symptoms may appear. On waking the patient remembers nothing of his illness; mydriasis remains some time, and there may be abnormality of speech and weakness of the limbs, but within four days health is reëstablished. In cases where the seeds have been swallowed, the symptoms may be much prolonged, and they seem to continue until all the seeds have been voided—perhaps this is due to the imperfect but continuous extraction of atropine by the intestinal juices.

Chronic poisoning by atropine may, from what has been stated, be of great importance in India. It is probable that its continuous effect would tend to weaken the intellect, and there is no reason for any incredulity with regard to its power as a factor of insanity. Rossbach has ascertained that if dogs are, day after day, dosed with atropine, they become emaciated; but a certain tolerance is established, and the dose has to be raised considerably after a time to produce any marked physiological effect.

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* In an English case of belladonna poisoning, the patient, a tailor, sat for four hours, moving his hands and arms as if sewing, and his lips as if talking, without uttering a word.

Physiological Action of Atropine.—From the numerous experiments on animals which have been performed for the purpose of elucidating the action of atropine, it is clear that the terminations of the vagus in the heart muscles are first excited, and then paralysed. The excitor-motor ganglion is also paralysed, and finally the heart itself; death resulting from heart paralysis. The respiratory disturbance is also to be ascribed to the vagus; the terminations in the lung are paralysed, and, at the same time, the poison circulating through the respiratory nervous centre stimulates it first, and then it also becomes finally paralysed. The small vessels are generally widened after a previous transitory narrowing. Organs containing unstriped muscular fibre are generally paralysed, as well as the end of the nerves regulating secretion—hence the dryness of the skin. The action on the iris is not thoroughly elucidated.

The *diagnosis* of atropine poisoning may be very difficult unless the attention of the medical man be excited by some suspicious circumstance. A child suffering from belladonna rash, with hot dry skin, quick pulse, and reddened fauces, looks not unlike one under an attack of scarlet fever. Further, as before mentioned, some cases are similar to rabies; and again, the garrulous delirium and the hallucinations of an adult are often very similar to those of *delirium tremens,* as well as to mania.

Post-mortem Appearances.—The *post-mortem* appearances do not seem to be very characteristic, save in the fact that the pupils remain dilated. The brain is usually hyperæmic, and in one case the absence of moisture seems to have been remarkable. The stomach and intestines may be somewhat irritated if the seeds, leaves, or other parts of the plant have been eaten; but the irritation is not constant if the poisoning has been by pure atropine, and still less is it likely to be present if atropine has been administered subcutaneously.

Treatment.—The great majority of cases recover under treatment. In 112 cases collected by F. A. Flack, 13 only were fatal (11·6 per cent.). The greater portion of the deaths in India are those of children and old people—persons of feeble vitality. The Asiatic treatment, which has been handed down by tradition, is the application of cold water to the feet; but the method which has found most favour in England is treatment by pilocarpine, a fifth of a grain or more being injected from time to time. Dr. Sydney Ringer and others have published a remarkable series of cases showing the efficacy of this treatment, which, of course, is to be combined where necessary with emetics, the use of the stomach-pump, &c.[*]

Separation of Atropine from Organic Tissues, &c.—From the contents of the stomach, atropine may be separated by acidulating strongly with sulphuric acid (15 to 20 cc. of dilute H_2SO_4 to 100 cc.), digesting for some time at a temperature not exceeding 70°, and then reducing any solid matter to a pulp by friction, and filtering, which can generally be effected by the aid of a filter-pump. The liver, muscles,[†] and coagulated blood, &c., may also be treated in a precisely similar way. The acid liquid thus obtained, is first, to remove impurities, shaken up with amyl alcohol, and after the separation of the latter in the usual manner, it is agitated with chloroform, which will take up any of the remaining amyl alcohol,[‡] and also serve to purify further. The chloroform is then removed by a pipette (or the separating flask before described), and the fluid made alkaline, and shaken up with ether, which, on removal, is allowed to evaporate spontaneously. The residue will be found to contain atropine, if present, and, possibly, sulphate of ammonia. If the latter is suspected, the residue should be treated with absolute alcohol, in which ammonia sulphate is insoluble.

From the urine,[§] atropine may be extracted by acidifying with sulphuric acid, and agitation with the same series of solvents. Atropine has been separated from putrid matters long after death, nor does it appear to suffer any decomposition by the ordinary analytical operations of evaporating solutions to dryness at 100°. In other words, there seems to be no necessity for operations *in vacuo,* in attempts at separating atropine.

2. HYOSCYAMINE.

This powerful alkaloid is contained in small quantities in datura and belladonna; but its chief source is the *Hyoscyamus niger* and

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[*] See, for Dr. Ringer's cases, *Lancet,* vol. i., 1876, p. 346. Refer also to *Brit. Med. Journ.,* vol. i., 1881, p. 594; *Ib.,* p. 659.

[†] Neither amyl alcohol nor chloroform removes atropine from an acid solution.

[‡] Atropine goes into the blood, and appears to be present in the different organs in direct proportion to the quantity of blood they contain. Dragendorff has found in the muscles of rabbits fed upon belladonna sufficient atropine for quantitative estimation.

[§] Dragendorf has found atropine in the urine of rabbits fed with belladonna; the separation by the poison is so rapid that it often can only be recognised in the urine during the first hour after the poison has been taken

Hyoscyamus alba (black and white henbane): it is also found in the *Duboisia myoporoides.* The latter plant was considered to contain a new alkaloid, "*Duboisine,*" but duboisine has not been shown to be in any way distinct from hyoscyamine. Ladenburg's hyoscine accompanies hyoscyamine, and is an isomeride of both atropine and hyoscyamine; its chemical reactions are similar to those of hyoscyamine, as well as its physiological effects.*

Hyoscyamine ($C_{17}H_{23}NO_3$), as separated in the course of analysis, is a resinoid, sticky, amorphous mass, difficult to dry, and possessing a tobacco-like odour. It can, however, be obtained in well-marked odourless crystals, which melt at 90°, a portion subliming unchanged. According to Thorey,† hyoscyamine crystallises out of chloroform in rhombic tables, and out of benzene in fine needles; but out of ether or amyl alcohol it remains amorphous. When perfectly pure, it dissolves with difficulty in cold, but more readily in hot, water; if impure, it is hygroscopic, and its solubility is much increased. In any case, it dissolves easily in alcohol, ether, chloroform, amyl alcohol, benzene, and dilute acids. Hyoscyamine neutralises acids fully, and forms crystallisable salts, which assume for the most part the form of needles. It is isomeric with atropine.

Pharmaceutical and other Preparations of Henbane.—The leaves are alone officinal in the European pharmacopœias; but the seeds and the root, or the flowers, may be met with occasionally, especially among herbalists. The table‡ (p. 348) will give an idea of the alkaloidal content of the different parts of the plant.

In order to ascertain the precentage of the alkaloid in any part of the plant, the process followed by Thorey has the merit of simplicity. The substance is first exhausted by petroleum ether, which frees it from fat; after drying, it is extracted with 85 per cent. alcohol at a temperature not exceeding 40°. The alcoholic extracts are then united, the alcohol distilled off, and the residue filtered. The filtrate is now first purified by agitation with petroleum ether, then saturated by ammonia, and shaken up with chloroform. The latter, on evaporation, leaves the alkaloid only slightly impure, and after washing with distilled water, if dissolved in dilute sulphuric acid, a crystalline sulphate may be readily obtained.

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* See *Ber. der Deutsch. Chem. Gesell.*, 13. 1549 to 1554. By boiling hyoscine hydro-chloride with animal charcoal, and then precipitating with auric chloride, a good crystalline compound, melting at 198°, can be obtained.

† *Pharm. Zeitschr. f. Russl.*, 1869

‡ This table, taken from Dragendorff's *Chemische Werthbestimmung einiger Starkwirkenden Droguen,* embodies the researches of Thorey.

TABLE XVI.—HENBANE—ALKALOIDAL CONTENT OF VARIOUS PARTS OF THE PLANT.

	Plant Destitute of Flowers.				Plant in Flower.				Plant in Fruit.			
	Hyosc.-Albus.		Hyosc.-Niger.		Hyosc.-Albus.		Hyosc.-Niger.		Hyosc.-Albus.		Hyosc.-Niger.	
	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.	1868.	1869.
Seeds, ...	....	....	....	....	....	...	....	..	0·162	0·172	0·075	0·118
Leaves, ...	0·588	0·469	0·154	0·192	0·359	0·329	0·147	0·206	0·211	0·153	0·065	0·110
Stalk, ...	0·012	....	0·070	0·017	0·036	0·048	0·032	0·030	0·027	0.029	0·009	0·010
Root, ...	0·128	0·176	0·027	0·080	0·146	0·262	0·127	0·138	0·106	0·086	0·028	0·056

A tincture and an extract of henbane leaves are officinal in most pharmacopœias; an extract of the seeds in that of France.

An oil of hyoscyamus is officinal in all the continental pharmacopœias; but not in the British.

An ointment, made of one part of the extract to nine of simple ointment, is officinal in the German.

The tincture (after distilling off the spirit) and the extracts (on proper solution) may be conveniently titrated by Mayer's reagent (p. 234), which, for this purpose, should be diluted one-half; each cc. then, according to Dragendorff, equalling 6·98 mgrms. of hyoscyamine. Kruse found 0·042 per cent. of hyoscyamine in a Russian tincture, and ·28 per cent. in a Russian extract. Any preparation made with extract of henbane will be found to contain nitrate of potash, for Attfield has shown the extract to be rich in this substance. The ointment will require extraction of the fat by petroleum ether; this accomplished, the determination of its strength is easy.

The oil of hyoscyamus is poisonous, and contains the alkaloid. An exact quantitative research is difficult; but if 20 grms. of the oil are shaken up for some time with water acidified by sulphuric acid, the fluid separated from the oil, made alkaline, shaken up with chloroform, and the latter removed and evaporated, sufficient will be obtained to test successfully for the presence of the alkaloid, by its action on the pupil of the eye.

Dose and Effects.—The dose of the uncrystalline hyoscyamine is 6 mgrms. ($\frac{1}{10}$ grain), carefully increased. I have seen it extensively used in asylums to calm violent or troublesome maniacs. 32 mgrms. (½ grain) begin to act within a quarter of an hour; the face flushes, the pupils dilate, there is no excitement, all muscular motion is enfeebled, and the patient remains quiet for many hours, the effects from a single dose not uncommonly lasting two days. 64·8 mgrms. (1 grain) would be a very large, and possibly fatal, dose. The absence of delirium or excitement, with full doses of hyoscyamine, is a striking contrast to the action of atropine, in every other respect so closely allied; yet there are cases on record showing that the henbane root itself has an action similar to that of belladonna, unless indeed one root has been mistaken for another—*e.g.*, Sonnenschein relates the following ancient case of poisoning:—In a certain cloister the monks ate by error the root of henbane. In the night they were all taken with hallucinations, so that the pious convent was like a madhouse. One monk sounded at midnight the matins, some who thereupon came into chapel could not read, others read what was not in the book, others sang drinking songs—in short, there was the greatest disturbance.

Separation of Hyoscyamine from Organic Matters.—The isolation of the alkaloid from organic tissues or fluids, in cases where a medicinal preparation of henbane, or of the leaves, root, &c., has been taken, is possible, and should be carried out on the principles already detailed. Hyoscyamine is mainly identified by its power of dilating the pupil of the eye. It is said that so small a quantity as ·0083 mgrm. ($\frac{1}{4000}$ grain) will in fifteen minutes dilate the eye of a rabbit. It is true that atropine also dilates the pupil; but if sufficient of the substance should have been isolated to apply other tests, it can be distinguished from atropine by the fact that the latter gives no immediate precipitate with platinic chloride, whilst hyoscyamine is precipitated by a small quantity of platinic chloride and dissolved by a larger amount.

Hyoscyamine gives precipitates with tincture of iodine, chloride of gold, and most of the common alkaloidal reagents, but exhibits no peculiar reaction. The observation of Kletzinsky,* that the action of soda-lye changes hyoscyamine into ammonia and santonin might, if correct, probably be utilised in identifying the alkaloid.

3. SOLANINE.

Solanine is an alkaloid found in all parts of the plants belonging to the *nightshade* or *solanum* order. The common edible potato-plant (*Solanum tuberosum*), the nightshade (*Solanum nigrum*), and the *Solanum dulcamara*, or bitter-sweet, are all common plants in England. The amount of solanine in the juice or the berries of the *Solanum nigrum*, as well as that of the *S. dulcamara*, has been estimated at ·3 per cent. The yield of the leaves of the young potato tubers is said to be about ·03 per cent., fully mature tubers contain but traces of solanine.

Solanine ($C_{43}H_{69}NO_{16}$) may be obtained when pure in good, colourless, glittering needles, the form of the crystal being that of the right-angled prism. The reaction of the crystals is weakly alkaline; the taste is somewhat bitter and pungent. Solanine is soluble in 8000 parts of boiling water, 4000 parts of ether, 500 parts of cold, and 125 of boiling water. It dissolves well in hot amyl alcohol, but is scarcely soluble in benzene. An aqueous solution froths on shaking, but not to the degree possessed by saponine solutions.

The amyl alcohol solution has the property of gelatinising when cold. It does this if even so little as 1 part of solanine is dissolved in 2000 of hot amyl alcohol. The jelly is so firm that the vessel may be inverted without any loss. This peculiar property is one of the most important tests for the presence of solanine. The hot ethylic alcohol solution will, on cooling, also gelatinise, but a stronger solution is required. From very dilute alcoholic solutions (and especially with slow cooling) solanine may be obtained in crystals. In dilute mineral acids solanine dissolves freely, and forms salts, which for the most part have an acid reaction and are soluble in alcohol and in water, but with difficulty in ether. The compounds with the acids are not very stable, and several of them are broken up on warming the solution, solanine separating out from the aqueous solutions of the solanine salts. The alkaloid may be precipitated by the fixed and volatile alkalies, and by the alkaline earths. Solanine will stand boiling with strongly alkaline solutions without decomposition; but dilute acids, on warming, readily split it up into a sugar and solanidine:—

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* *Schweiz. Wochenschr. Pharm.*, 1866-85.

$$C_{43}H_{69}NO_{16}+3H_2O = C_{25}H_{39}NO+3C_6H_{12}O_6.$$

Solanine might thus be mistaken for a non-nitrogenous glucoside. Solanidine has stronger basic characters than solanine. It melts at 208°, is alkaline in reaction, tastes bitter, is capable of being sublimed without decomposition, is soluble in alcohol, in ether, and in benzene, but only slightly soluble in water. It forms with mineral acids scarcely crystallisable salts. By heating solanine in alcoholic solution with ethyl iodide in closed tubes, and then treating the liquid with ammonia, ethyl solanine in well-formed crystals can be obtained. Solanine is precipitated by phosphomolybdic acid, but by very few other substances. It gives, for example, no precipitate with the following reagents:—Platinic chloride, gold chloride, mercuric chloride, potassic bichromate, and picric acid. Tannin precipitates it only after a time. Sodic phosphate gives a crystalline precipitate of solanine phosphate, if added to a solution of solanine sulphate. Both solanine and solanidine give with nitric acid at first a colourless solution, which, on gentle warming, passes into blue, then into light-red, and lastly becomes weakly yellow. Solanine, dissolved in strong sulphuric acid, to which a little Fröhde's reagent is added, at first colours the fluid light-brown; after standing some time the edges of the drop become reddish-yellow, and finally the whole a beautiful cherry-red, which gradually passes into dark-violet, when violet-coloured flocks separate.

Poisoning from Solanine.—Poisoning from solanine has been, in all recorded cases, induced, not by the pure alkaloid (which is scarcely met with out of the laboratory of the scientific chemist), but by the berries of the different species of solanum, and has for the most part been confined to children. The symptoms in about twenty cases,* which may be found detailed in the medical literature of this century, have varied so greatly that the most opposite phenomena have been witnessed as effects of poisoning by the same substance. The most constant phenomena are a quick pulse, laboured respiration, great restlessness, and hyperæsthesia of the skin. Albumen in the urine is common. Nervous symptoms, such as convulsions, aphasia, delirium, and even catalepsy, have been witnessed. In some cases there have been the symptoms of an irritant poison—diarrhœa, vomiting, and pain in the bowels : in many cases dilatation of the pupil has been observed.

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* See "Death of three Children by *S. nigrum*;" Hirtz., *Gaz. Med. de Strasbourg*, 1842; Maury, *Gaz. des Hôp.*, 1864; J. B. Montane, *Chim. Med.*, 1862; Magne, *Gaz. des Hôp.*, 1869; Manners, *Ed. Med. Journ.*, 1867. Cases of poisoning by bitter sweet berries are recorded in *Lancet*, 1856; C. Bourdin, *Gaz. des Hôpitaux*, 1864; Bourneville, the berries of *S. tuberosum*, *Brit. Med. Journ.*, 1859.

Rabbits are killed by doses of ·1 grm. per kilo. The symptoms commence in about ten minutes after the administration, and consist of apathy, and a low temperature ; the breathing is much slowed. Convulsions set in suddenly before death, and the pupils become dilated. The *post-mortem* appearances in animals are intense redness and injection of the meninges of the cerebellum, of the medulla oblongata, and the spinal cord. Dark-red blood is found in the heart, and the kidneys are hyperæmic. The intestinal mucous membrane is normal.

Separation of Solanine from the Tissues of the Body.—Dragendorff has proved the possibility of separating solanine from animal tissues by extracting it from a poisoned pig. The best plan seems to be to extract with cold dilute sulphuric acid water, which is then made alkaline by ammonia, and shaken up with warm amyl alcohol. This readily dissolves any solanine. The peculiar property possessed by the alkaloid of gelatinising, and the play of colours with Fröhde's reagent, may then be essayed on the solanine thus separated.

4. CYTISINE.

The laburnum tree, *Cytisus laburnum,* so common in shrubberies, is intensely poisonous. The flowers, bark, wood, seeds, and the root have all caused very serious symptoms. The only active principle hitherto discovered is an alkaloid termed *Cytisine,* which may be extracted from the plant by water acidulated with sulphuric acid, neutralisation with lime, subsequent treatment of the filtrate with acetate of lead, and precipitation by tannic acid. To obtain the alkaloid pure, it is finally crystalised as a nitrate.

Cytisine ($C_{20}H_{27}N_3O$) is in white, radiating crystals, of a bitter, weakly caustic taste, and without odour. It has a strong alkaline reaction, is soluble in every proportion in water, and is also very soluble in spirit. It scarcely dissolves in anhydrous ether, chloroform, benzene, and bisulphide of carbon. It may be sublimed at 154·5° in hydrogen, in the form of very long needles and small leaflets ; at higher temperatures it melts to a yellow oily fluid, again becoming crystalline on cooling. Cytisine is one of the strongest bases existing in plants ; it precipitates the earths and oxides of the heavy metals from solutions of the chlorides, and even in the cold expels ammonia from its combinations.

The nitrate of cytisine ($C_{20}H_{27}N_3O,2NHO_3+2H_2O$) forms large, thick, transparent monoclinic prisms, losing the water of crystallisation at 100° to 110°, and becoming opaque : it has an acid reaction. It is insoluble in ether, and almost so in absolute alcohol ; but soluble in water and weak spirit. The rest of the salts are easily decomposed. A hydrochlorate ($C_{20}H_{27}N_3O,4HCl+3H_2O$), a platinum salt of an orange-yellow colour ($C_{20}H_{27}N_3O2HCl,2PtCl_2$), a gold salt, at first yellow or flocculent, but later changing into needles ($C_{20}H_{27}N_3O,2HCl,2AuCl_3$), a mercury salt ($C_{20}H_{27}N_3O,4HgCl$), and many others, can be obtained.

Concentrated sulphuric acid dissolves cytisine without colour ; if to the solution is added a drop of nitric acid, it becomes orange-yellow, and on addition of a crystal of potassic bichromate, first yellow, then dirty brown, and lastly green. Concentrated nitric acid dissolves the base in the cold without colour, but, on warming, it becomes orange-yellow. Picric, tannic, and phosphomolybdic acids, potassic, mercuric, and potass. cadmium iodides, and iodine with potassic iodide, all give precipitates. Neither potassic bichromate nor mercuric chloride precipitates cytisine, even though the solution be concentrated.

Effects on Animals.—W. Marmé found subcutaneous doses of from 30 to 40 mgrms. fatal to cats ; death was from paralysis of the respiration, and could be avoided by artificial respiration. Cattle are sometimes accidentally poisoned by laburnum. An instance of this is recorded in the *Veterinarian,* (vol. lv., p. 92). In Lanark a storm had blown a large laburnum tree down to the ground ; it fell into a field in which some young heifers were grazing, and they began to feed on the leaves and pods. Two or three died, and three more were ill for some time, but ultimately recovered.

The laburnum, however, does not always have this effect, for there is a case related in the *Gardener's Chronicle,* in which five cows browsed for some time on the branches and pods of an old laburnum tree that had been thrown aside. Rabbits and hares are said to feed eagerly, and without injury, on the pods and branches.

Effects on Man.—The sweet taste of many portions of the laburnum tree, as well as its attractive appearance, has been the cause of many accidents. F. A. Falck has been able to collect from medical literature no less than 155 cases—120 of which were those of the accidental poisoning of children : only 4 (or 2·6 per cent.) however, died, so that the poison is not of a very deadly character.

One of the earliest recorded cases is by Christison.[*] A servant girl of Inverness, in order to excite vomiting in her fellow-servant (the cook), boiled some laburnum bark in soup; very soon after partaking of this soup, the cook experienced violent vomiting, which lasted for thirty-six hours; she had intense pain in the stomach, much diarrhœa, and great muscular weakness; she appears to have suffered from gastro-intestinal catarrh for some time but ultimately recovered.

Vallance[†] has described the symptoms observed in the poisoning of 58 boys, who ate the root of an old laburnum tree, being allured by its sweet taste. All were taken ill with similar symptoms, differing only in severity; two who had eaten half an ounce (nearly 8 grms.) suffered with especial severity. The symptoms were first vomiting, then narcosis, with convulsive movements of the legs and strange movements of the arms: the pupils were dilated. This dilatation of the pupil Sedgwick also saw in the poisoning of two children who ate the root. On the other hand, when, the flower, seeds, or other portions of the laburnum have been eaten, the symptoms are mainly referable to the gastro-intestinal tract, consisting of acute pain in the stomach, vomiting, and diarrhœa. On these grounds, it is therefore more than probable that there is another active principle in the root, differing from that which is in those portions of the tree exposed to the influence of sunlight.[‡]

The *post-mortem* appearances are, as far as known, in no way characteristic.

VII.—THE ALKALOIDS OF THE VERATRUMS.

The alkaloids of the veratrums have been recently investigated by Dr. Alder Wright and Mr. A. P. Luff.[§] From their researches it appears that both the *Veratrum viride* and the *Veratrum album* contain several distinct alkaloids, some of which are crystalline, others amorphous, and two only of which are sternutatory. The proportions of the different alkaloids in the *V. album* and *V. viride* is given as about the following per kilo. of roots :—

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[*] *Ed. Med. Journ.*, 1843.

[†] *Brit. Med. Journ.*, 1875.

[‡] See also a case related by Dr. Popham, in which ten children ate laburnum seeds; the pupils were dilated. They all recovered. *B. and F. Med. Chir. Review*, Ap., 1863; also a case reported by H. Usher, *Med. Times and Gazette*, Sep. 15, 1862.

[§] "The Alkaloids of the Veratrums," by C. R. Alder Wright, D. Sc., and A. P. Luff, *Journ. Chem. Soc.*, July, 1879. "The Alkaloids of *Veratrum Viride*," by C. R. Alder Wright, D. Sc., *Ib.*, 1879.

TABLE XVII.—ALKALOIDS IN THE VERATRUMS.

	V. Album.	V. Viride.
Jervine, ...	1·3 grm.	·2 grm.
Pseudo-jervine. . .	·4 ,,	·15 ,,
Rubi-jervine, . . .	.25 ,,	·02 ,,
Veratralbine, . . .	2·2 ,,	Traces.
Veratrine, ...	·05 ,,	Less than ·004 grm.
Cevadine, . . . , .	Absent.	·43 grm.

Jervine ($C_{26}H_{37}NO_3,2H_2O$), when anhydrous, melts at 237° to 239° : it forms a very insoluble sulphate and sparingly soluble nitrate and hydrochloride. Treated with strong sulphuric acid it dissolves to a yellow fluid, which becomes successively dark-yellow, brownish-yellow, and then greenish. After standing a little time a green tint is developed, afterwards becoming dark-green. The green shade is immediately developed by diluting with water.

Pseudo-jervine ($C_{29}H_{43}NO_7$) crystallises anhydrous, and melts at 299°, forming a crystalline sulphate and hydrochloride ; it gives the same play of colours as jervine, and has no sternutatory properties.

Rubi-jervine ($C_{26}H_{43}NO_2$) is a crystallisable base wholly different from jervine, yet probably closely allied to it. It forms a light yellow, indistinctly crystalline gold salt ($C_{26}H_{43}NO_2,HCl,AuCl_3$) : it gives a different play of colours from jervine with sulphuric acid. The concentrated acid dissolves rubi-jervine to a clear yellow fluid, becoming successively dark-yellow, brownish-yellow, and brownish blood-red, changing after several hours to a brownish-purple. On diluting slightly with water the brownish-red liquid, it becomes successively crimson, purple, dark-lavender, dark-violet, and ultimately light-indigo. Its hydrochloride and sulphate are both more soluble than either of the corresponding salts of jervine or pseudo-jervine.

Veratralbine ($C_{28}H_{43}NO_5$), an amorphous non-sternutatory base, gives, when a speck of the substance is dissolved in sulphuric acid, a play of colours, becoming successively yellow, dark-yellow, brownish-orange, and brownish blood-red with a strong green fluorescence. It yields no acid on saponification.

Veratrine ($C_{37}H_{53}NO_{11}$) is a crystallisable alkaloid, which is a powerful irritant of the sensory nerves of the mucous membrane, and excites violent sneezing. Treated with concentrated sulphuric acid, it dissolves with a yellow colour, deepening into orange, then into blood-red, and finally passing into carmine-red. If the freshly-prepared sulphuric acid solution is now treated with bromine water, a beautiful purple colour is produced. Concentrated hydrochloric acid dissolves veratrine without the production of colour, but, with careful warming, it becomes beautifully red. This reaction is very delicate, occurring with ·17 mgrm. On saponification veratrine yields veratric acid.

Cevadine, $C_{32}H_{49}NO_9$ (Merck's veratrine).—It has powerful sternutatory properties, and, under the influence of saponifying agencies, yields cevadic, methyl crotonic, or tiglic acids. It is crystalline, and has a melting point of from 205° to 206°.

The method which Dr. Wright adopted to extract and separate these alkaloids from the root of *V. album* and *V. viride*, essentially consisted in exhausting with alcohol, to which a little tartaric acid had been added, filtering, distilling off the alcohol, dissolving the residue in water, alkalising with caustic soda, and shaking up with ether. The ethereal solution was next separated, and then washed with water containing tartaric acid, so as to obtain a solution of the bases as tartrates: in this way the same ether could be used over and over again. Ultimately a rough separation was made by means of the different solubilities in ether, pseudo-jervine being scarcely soluble in this medium, whilst jervine, veratralbine, veratrine, and cevadine are very soluble in it.

Commercial Veratrine has hitherto consisted of a mixture of alkaloids, and is, indeed, neither prepared from *V. album* nor *V. viride*, but from the seeds of *Sabadilla officinalis*.* As met with in commerce it is a white semi-crystalline powder without smell, but of a bitter taste, and alkaline reaction; the smallest portion applied to the nasal mucous membrane causes sneezing. It is scarcely soluble in water, dissolves easily in alcohol, chloroform, and ether and amyl alcohol; it is somewhat insoluble in petroleum ether. It dissolves in acid holding water, and is precipitated by alkalies. The precipitate becomes gradually crystalline, and is soluble in excess of potash. Commercial veratrine gives the reaction with hydrochloric acid, as well as that with sulphuric acid and afterwards bromine.

Pharmaceutical Preparations.—The alkaloid is officinal in the English, American, and Continental pharmacopœias. There is also an *unguentum veratriæ*—strength about 1·6 per cent. In the London pharmacopœia of 1851 there used to be a wine of white hellebore, the active principle of 20 parts of the root by weight being contained in 100 parts by measure of the wine. Using Dr. Wright's results, such a wine would contain about ·084 per cent. of total alkaloids. Of the green hellebore there is a tincture (*tinc-*

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* The Alkaloid of the Sabadilla Seeds are (1) Veratrine, (2) Cevadine, and (3) in small quantity only, Cevadilline ($C_{34}H_{53}NO_8$)

tura veratrum viride), to make which four parts by weight of the root are exhausted by 20 parts by measure of spirits; the probable strength is ·016 per cent. of total alkaloids.

Fatal Dose.—The maximum dose of the commercial alkaloid is laid down as 10 mgrms. (·15 grain), which can be taken safely in a single dose, but nothing sufficiently definite is known as to what is a lethal dose 1·3 grm. of the powdered rhizome has caused death, and on the other hand, ten times that quantity has been taken with impunity, so that at present it is quite an open question.

Effects on Animals—Physiological Action.—Experiments on animals have proved that the veratrums act on the sensory nerves of the skin, and those of the mucous membranes of the nose and intestinal canal; they are first excited, afterwards paralysed. It exercises a peculiar influence on voluntary muscle; the contractility is changed, so that when excited, there is a long-continuing contraction, and from a single stimulus more heat is disengaged than with healthy muscle; the motor nerves are also affected. The respiration, at first quickened, is then slowed, and finally paralysed. The heart's action is also first quickened, the blood-pressure at the same time is raised, and the small arteries narrowed in calibre; later follow sinking of the pressure, slowing of the heart, and dilatation of the vessels, and the heart becomes finally paralysed.

Effects on Man.—Poisoning by veratrum, sabadilla, or pharmaceutical preparations containing veratrine, is not common. Plenk witnessed a case in which the external application of sabadilla powder to the head caused delirium, and Lentin also relates a case in which an infant at the breast seems to have died from an external application made for the purpose of destroying lice. In both instances, however, there is a possibility that some of the medicament was swallowed.

Blas recorded, in 1861, the case of two children who drank a decoction of white hellebore, the liquid being intended as an external application to an animal. They showed serious symptoms, but ultimately recovered.

A scientific chemist took 3·8 grms. (58 grains) of the tincture of green hellebore for the purpose of experiment. There followed violent symptoms of gastric irritation, vomiting, and diarrhœa, but he also recovered.*

Casper relates the poisoning of a whole family by veratrum; from the stomach of the mother (who died) and the remains of the repast (a porridge of lentils) veratrine was separated.

Faber † recorded the poisoning of thirty cows by veratrum; eight died, and it is noteworthy that violent poisonous symptoms were produced in animals partaking of their flesh and milk.

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* *Med. Times and Gazette*, Jan. 3, 1863.

† *Zeitschr. f. Staatsarzneik.*, 1862.

The symptoms appear soon after the ingestion, and consist of a feeling of burning in the mouth, spreading downwards to the stomach, increased secretion of saliva, and difficulty of swallowing; then follow violent vomiting and diarrhœa, with great pain in the bowels, often tenesmus; there is also headache, giddiness, a feeling of anxiety, and the pupils are dilated. The consciousness is ordinarily intact; the pulse is weak and slow, and the breathing embarrassed; the skin is benumbed. There may be also formicating feelings, and twitchings in the muscles, with occasionally the tetanic cramps, which are constantly seen in frogs. In cases which end fatally, the disturbance of the breathing and circulation increases, and death takes place in collapse.

An important case of slow poisoning is on record,* in which two brothers, aged twenty-one and twenty-two years, died after nine and eleven weeks of illness, evidently from repeated small doses of the powder of *Veratrum album*. They became very weak and thin, suffered from diarrhœa and bloody stools, sleeplessness, disturbance of the intellect, and delirium.

The *post-mortem* signs do not appear distinctive; even in the case just mentioned—in which one would expect to find, at all events, an extensive catarrh of the intestinal canal—the results seems to have been negative.

Separation from Organic Matters.—The method of Stas (by which the organic matters, whether the contents of the stomach or the tissues, are treated with alcohol, weakly acidified by tartaric acid) is to be recommended. After filtering, the alcoholic extract may be freed from alcohol by careful distillation, and the extract taken up with water. By now acidifying gently the watery extract, and shaking it up with ether and chloroform, fatty matters, resinous substances, and other impurities, are removed, and it may then be alkalised by soda or potash, and the veratrine extracted by ether. The residue should be identified by the hydrochloric acid and by the sulphuric acid and bromine reactions; care should also be taken to ascertain whether it excites sneezing.

VIII.—PHYSOSTIGMINE.

The ordeal bean of Calabar (*Physostigma faba*) is a large, all but tasteless kidney-shaped bean, about an inch in length and half an inch thick; its convex edge has a furrow with elevated ridges, and is pierced by a small hole at one extremity. The integuments are coffee-brown in colour, thin, hard, and brittle; they enclose two white cotyledons, easily pulverisable, and weighing on an average 3·98 grms. (61 grains). The seed contains at least one alkaloid, termed *Physostigmine* (first separated in 1864 by Jobst and Hesse) and possibly a second, according to Harnach and Witkowsky, who have discovered in association with physostigmine a new alkaloid, which they call *Calabarine*, and which differs from physostigmine in being insoluble in ether and soluble in water. It is also soluble in alcohol; and further, the precipitate produced by potassium iodohydrargyrate in calabarine solutions is insoluble in alcohol.

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* Nivet and Geraud, *Gaz. Hebdom*, 1861.

Physostigmine, or Eserine, is not easily obtained in a crystalline state, being most frequently extracted as a colourless varnish, drying into brittle masses. It is, however, quite possible to obtain it in the form of partially-crystalline crusts, or even rhombic plates, by care being taken to perform the evaporation, and all the operations, at as low a temperature as possible, and preferably in a dimly-lit room; for, if the temperature rises to 40°, much of the alkaloid will be decomposed. Hesse recommends that the beans be extracted by alcohol, the alcoholic solution alkalised by sodic carbonate, and the liquid shaken up with ether, which will retain the alkaloid. The ether solution is now separated, and acidified slightly with very dilute sulphuric acid; the fluid, of course, separates into two layers, the lower of which contains the alkaloid as a sulphate, the upper is the ether, which is withdrawn, and the acid fluid passed through a moist filter. The whole process is then repeated as a purification.

Again, Vee, who has repeatedly obtained the alkaloid in a crystalline condition, directs the extraction of the beans by alcohol, the alcoholic solution to be treated as before with sodic carbonate, and then with ether; the ethereal solution to be evaporated to dryness, dissolved in dilute acid, precipitated by sugar of lead, and the filtrate from this precipitate alkalised by potassic bicarbonate, and then shaken up with ether. The ethereal solution is permitted to evaporate spontaneously, the crystalline crusts are dissolved in a little dilute acid, and the solution is lastly alkalised by potassic bicarbonate, when, after a few minutes, crystalline plates are formed.

The formula ascribed to physostigmine is $C_{15}H_{12}N_3O_2$. It is strongly alkaline, fully neutralising acids and forming tasteless salts. It is easily melted, and perhaps partly decomposed, at a temperature of 45°; at 100° it is certainly changed, becoming of a red colour, and forming with acids a red solution. It dissolves easily in alcohol, ether, chloroform, and bisulphide of carbon, but is not easily soluble in water.

The salts formed by the alkaloid with the acids are generally hygroscopic and uncrystallisable, but an exception is met with in the hydrobromide, which crystallises in stellate groups.* If CO_2 is passed into water containing the alkaloid in suspension, a clear solution is obtained; but the slightest warmth decomposes the soluble salt and reprecipitates the alkaloid. The hydrargyc hydroiodide ($C_{15}H_{21}N_3O_2,HI,2HgI$) is a white precipitate, insoluble in water, becoming yellow on drying, soluble in ether and alcohol, and from such solutions obtained in crystalline prismatic groups. A heat of 70° melts the crystals, and they solidify again in the amorphous condition.

The most delicate chemical test is probably that of Dragendorff—viz., the production of a marked red colour in a solution of the sulphate by means of bromine water. It succeeds with less than ·06 of a mgrm.†

Concentrated sulphuric acid dissolves physostigmine with the production of a yellow colour, changing into olive-green; nitric acid (conc.) also gives a yellow colour. Ammonia and the carbonated alkalies precipitate the alkaloid from an acetic acid solution in the form of oily drops. Other precipitants are tannic acid, which throws down from a solution of the hydrochloride a reddish-white flocculent precipitate, not easily soluble in hydrochloric acid; chloride of gold, a blue, with quick reduction of gold; mercuric chloride, a reddish-white precipitate, easily soluble in hydrochloric acid. It gives no precipitate with platinic chloride.

Pharmaceutical Preparations.—The only preparation officinal in this country and abroad is a spirituous extract (*Extractum physostigmatis*), used principally for external application, the dose of which is not more than 18·1 mgrms. (·18 grain).

Effects on Animals.—A large number of experiments have been made upon animals with physostigmine, most of them with the impure alkaloid, which is a mixture of calabarine and physostigmine. Now, the action of calabarine seems to be the opposite to that of physostigmine—that is, it causes tetanus. Hence, these experiments are not of much value, unless the different proportions of the alkaloids were known. Harnack and Witkowsky ‡ made, however, some researches with pure physostigmine, of which the following are the main results: The smallest fatal dose for rabbits is 3 mgrms. per kilo.; cats about the same; while dogs take from 4 to 5 mgrms. per kilo. Frogs, under the influence of the alkaloid, lie paralysed without the power of spontaneous movement, and the sensibility is diminished; later, the breathing ceases, and the reflex irritability becomes extinguished. The activity of the heart is through ·5 mgrm. slowed, but at the same time strengthened.

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* M. Duquesnel, *Pharm. J. Trans.* [3], v., 847.

† Husemann's *Jahresbericht.* 1872.

‡ *Arch. f. Pathol. u. Pharm.* 1876, Bd. v.

The warm-blooded animals experimented upon show rapid paralysis of the respiratory centre, but the animal by artificial respiration can be saved. Fibrillar muscular twitching of all the muscles of the body are observed. Death follows in all cases from paralysis of the respiration. Experiments (first by Bexold, then by Fraser and Bartholow, and lastly by Schroff) have amply shown that atropine is, to a certain extent, an antidote for physostigmine poisoning. Fraser also maintains an antagonism between strychnine and physostigmine, and Bennet that chloral hydrate is antagonistic to physostigmine.

Effects on Man.—The bean has long been used by the superstitious tribes of the West Coast of Africa as an ordeal, and is so implicitly believed in that the innocent, when accused of theft, will swallow it, in the full conviction that their innocency will protect them, and that they will vomit up the bean and live. In this way, no doubt, life has been sacrificed. Christison experimented upon himself with the bean, and nearly lost his life. He took 12 grains, and was then seized with giddiness and a general feeling of torpor. Being alarmed at the symptoms, he took an emetic which acted. He was giddy, faint, and seemed to have lost all muscular power; the heart and pulse were extremely feeble, and beat irregularly. He afterwards fell into a sleep, and the next day he was quite well.

In August, 1864, forty-six children were poisoned at Liverpool by eating some of the beans, which had been thrown on a rubbish heap, being part of the cargo of a ship from the West Coast of Africa. A boy, aged six, ate six beans, and died. In April of the same year, two children, aged six and three years, chewed and ate the broken fragments of one bean; the usual symptoms of gastric irritation and muscular weakness followed, but both recovered. Physostigmine contracts the iris to a point; the action is quite local, and is confined to the eye to which it is applied. When administered internally, according to some, it has no effect on the eyes, but according to others, it has a weak effect in contracting the pupil. In any case, the difference of opinion shows that the effect, when internally administered, is not one of a marked character.

Physiological Action.—The physiological action of physostigmine is strikingly like that of nicotine, which it resembles in being a respiratory poison, first exciting, afterwards paralysing the vagus. Like nicotine, also, it produces a great loss of muscular power; it first excites, and then paralyses the intra-muscular terminations of the nerves; and, again, like nicotine, it induces a tetanus of the intestine. A difference between physostigmine and nicotine exists in the constant convulsive effects of the former, and in the greater influence on the heart of the latter.

Post-mortem Appearances.—But little is known relative to the *post-*

mortem appearances likely to be found in human poisoning; redness of the stomach and intestines is probably the chief sign.

Separation of Physostigmine.—For the extraction of physostigmine from the fluids of the body, Dragendorff recommends benzene: the alcoholic filtered extract (first acidified) may be agitated with such solvents as petroleum and benzene, in order to remove colouring matter; then alkalised and shaken up with benzene, and the latter allowed to evaporate spontaneously—all the operations being, as before stated, carried on under 40°. If much coloured, it may be purified according to the principles before mentioned. In cases where enough of the extract (or other medicinal preparation) has been taken to destroy life, the analyst, with proper care, would probably not have much difficulty in separating a small quantity of the active principle. It is rapidly eliminated by the saliva and other secretions. In most cases it will be necessary to identify physostigmine by its physiological activity, as well as by its chemical characters. For this purpose a small quantity of the substance should be inserted in the eye of a rabbit; if it contains the alkaloid in question, in twenty minutes, at the very latest, there will be a strong contraction of the pupil, and a congested state of the conjunctival vessels. Further researches may be made with a small quantity on a bird or frog. The chief symptoms observed will be those of paralysis of the respiratory and voluntary muscles, followed by death. If a solution is applied to the web of a frog's foot, the blood-vessels become dilated. Physostigmine appears, according to Dragendorff and Pander, to act as an irritant, for they always observed gastro-enteritis as a result of the poison, even when injected subcutaneously. The enhanced secretion from all mucous surfaces, and the enlargement of the blood-vessels, are also very constant symptoms. But of all these characteristics, the contraction of the pupil is, for the purposes of identification, the principal. A substance extracted from the tissues or other organic matters, in the manner mentioned, strongly contracting the pupil and giving the bromine reaction, would, in the present state of our knowledge, be indicative of physostigmine, and of that alone.

Fatal Dose of Physostigmine.—One mgrm. (·015 grain) as sulphate, given by Vee to a woman subcutaneously, caused vomiting, &c., after half an hour. A disciple of Gubler's took 2 mgrms. without apparent effect; but another mgrm., a little time after, caused great contraction of the pupil and very serious symptoms, which entirely passed off in four hours. It would thus seem that three times this (*i.e.*, 6 mgrms.) would be likely to be dangerous. If so, man is far more sensitive to physostigmine than dogs or cats; and 3 mgrms. per kilo.—that is about 205 mgrm. (3 grains)—would be much beyond the least fatal dose.

IX.—PILOCARPINE.

From the leaves of the jaborandi, *Pilocarpius pennatafolius* (Nat. Ord. *Rutaceæ*), two alkaloids have been separated—*jaborandi* and *pilocarpine.*

Jaborandi ($C_{10}H_{12}N_2O_3$) is a strong base, differing from pilocarpine in its sparing solubility in water, and more ready solubility in ether; its salts are soluble in water and alcohol, but do not crystallise. P. Ghastaing,[*] by treating pilocarpine with a large quantity of nitric acid, obtained nitrate of jaborandi, and operating in the same way with hydrochloric acid, obtained the hydrochloric of jaborandi; hence, it seems that jaborandi is derived from pilocarpine.

Pilocarpine ($C_{11}H_{16}N_2O_2$) is a soft gelatinous mass, but it forms with the mineral acids crystallisable salts. The nitrate and hydrochloride are at present much used in pharmacy. Pilocarpine gives a precipitate with phosphomolybdic acid, potassio-mercuric iodide, and most general alkaloidal reagents, but none are very distinctive. When a solution of gold chloride is added to one of pilocarpine, a salt falls, having the composition $C_{11}H_{16}N_2O_2,HCl+AuCl_3$. It is not very soluble in water (about 1 in 4600), and has been utilised for the estimation of pilocarpine. Pilocarpine fused with potash yields trimethylamine, carbon dioxide, butyric, and traces of acetic acid. Pilocarpine dissolves without the production of colour in sulphuric acid; but, with bichromate of potash and sulphuric acid, a green colour is produced. It may be extracted from an aqueous solution made alkaline by ammonia, by shaking up with chloroform or benzene.

Effects.—Pilocarpine, given subcutaneously in doses of about 32 mgrms. (½ grain), causes within five minutes a profuse perspiration and salivation, the face becomes flushed, and the whole body sweats; at the same time, the buccal secretion is so much increased that in a few hours over a pint may be secreted. The tears, the bronchial secretion, and the intestinal secretions, are also augmented; there are generally headache and a frequent desire to pass water; the pulse is much quickened, and the temperature falls from 4° to 1·4°: the symptoms last from two to five hours. Langley has shown that the over-action of the submaxillary gland is not affected by section either of the *chorda tympani,* or of the sympathetic supplying the gland. Although pilocarpine quickens the pulse of man, it slows, according to Langley,[†] the heart of the warm-blooded animals, and that of the frog. With regard to the frog, Dr. S. Ringer's researches are confirmatory. With large doses the heart stops in diastole. If to the heart thus slowed, or even when recently stopped, a minute quantity of atropine be applied, it begins to beat again. There is also a most complete antagonism between atropine and pilocarpine in other respects, atropine stopping the excessive perspiration, and relieving the headache and pain about the pubes, &c. Pilocarpine, given internally, does not alter the size of the pupil, but the sight may, with large doses, be affected. If a solution is applied direct to the eye, then the pupil contracts. No fatal case of its administration has occurred in man. The probable dangerous dose would be about 130 mgrms. (2 grains) administered subcutaneously. Pilocarpine must be classed among the heart poisons.

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[*] *Copt. Rend.*, vol. xciv., p. 223.

[†] "The Action of Jaborandi on the Heart," by J. N. Langley, B.A., *Journ. Anat and Physiol.*, vol. x., p. 187

X.—TAXINE.

The leaves and berries, and probably other parts of the common yew (*Taxus baccata*), are poisonous. The poison is probably due to an alkaloid (as yet imperfectly studied), which was separated by Marmé, and who called it *taxine*. Taxine is a snow-white powder of bitter taste, with difficulty soluble in water, but dissolving in alcohol, ether, and diluted acids. It gives with phosphomolybdic acid a canary-yellow precipitate, and with tannin a white precipitate, becoming crystalline on standing. Picric acid gives a yellow precipitate, and iodised potassium iodide reddish-brown crystals.* It may be extracted from fluids made ammoniacal by chloroform or benzene. Concentrated sulphuric acid strikes with it a red colour. The platinum, gold, and mercuric compounds are easily soluble.

Poisoning by Yew.—Falck has been able to collect no less than 32 cases of poisoning by different parts of the yew—9 were from the berries, and the rest from the leaves. They were all accidental; 20 persons died, or 62·5 per cent.

Effects on Animals—Physiological Action.—From the researches of Marmé-Borchers, it appears that taxine acts upon the nervous centres—the nervous trunks themselves and the muscles remaining with their excitability unimpaired, even some time after death. Taxine kills through paralysis of the respiration, the heart beating after the breathing has stopped. The leaves contain much formic acid, and their irritant action on the intestine is referred to this cause.

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* D. Amato and A. Capparelli: *Gaz. Chim. Ital.*, vol x., pp. 349–355; *Journ. Chem. Soc.*, 1880, p. 899.

Effects on Man.—Several deaths from yew have resulted in lunatic asylums from the patients chewing the leaves. For example, a few years ago, at the Cheshire County Asylum, a female, aged forty-one, was suddenly taken ill, apparently fainting, her face pale, her eyes shut, and pulse almost imperceptible. Upon the administration of stimulants she somewhat revived, but in a little while became quite unconscious. The pupils were contracted, and there were epileptiform convulsions, succeeded by stertorous breathing. These convulsions returned from time to time, the action of the heart became weaker, and there was a remarkable slowing of the respirations, with long intervals between the breathing. The woman died within an hour from the time when her illness was first observed, and within two hours of eating the leaves. Yew leaves were found in her stomach. In another case that occurred at the Parkside Asylum,* the patient died suddenly in a sort of epileptic fit. Yew leaves were again found in the stomach. In a case quoted by Taylor, in which a decoction of the leaves was drunk by a girl, aged 15, for the purpose of exciting menstruation, she took the decoction on four successive mornings. Severe vomiting followed, and she died eight hours after taking the last dose. In another case, there were also no symptoms except vomiting, followed by rapid death. Mr. Hurt, of Mansfield, has recorded a case of poisoning by the berries. The child died in convulsions before it was seen by any medical man.

From these and other recorded cases, the symptoms seem generally to be a quick pulse, fainting or collapse, nausea, vomiting, convulsions, slow respiration, and death, as a rule sudden and unexpected. We may suppose that the sudden death is really due to a rapid paralysis of the respiration, and suffocation.

Post-Mortem Appearances.—In the case of the girl who drank the decoction, nothing unusual was observed in the stomach or organs of the body; but when the leaves have been eaten, usually more or less congestion of the mucous membrane of the stomach, as well as of the bowels, is apparent. In the case of the child who ate the berries (Hurt's case), the stomach was filled with mucous and half-digested pulp of the berries and seeds. The mucous membrane was red in patches and softened, and the small intestines were also inflamed.

XI.—CURARINE.

Commercial curare is a black, shining, resinoid mass, about 83 per cent. of which is soluble in water, and 79 in weak spirit. It is a complicated mixture of vegetable extracts, from which, however, a definite principle possessing basic characters (*curarine*) has been separated.

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* *Phar. Journ.* [3], No. 294.

The extract is an arrow poison prepared by different tribes of Indians in South America, between the Amazon and the Orinoco; therefore, samples are found to vary much in their poisoning properties, although it is noticeable that qualitatively they are the same, and produce closely analogous symptoms. It is supposed that some of the curare is derived from different species of strychnia. This is the more probable, because, as before stated, the South American strychnines paralyse, and do not tetanise. It is not unlikely that the active principles of curare (or woorari) may be methyl compounds similar to those which have been artificially prepared, such as methyl strychnine and methyl brucine, both of which have a curare-like action.

Curarine was first separated by Preyer in a crystalline form in 1865. He extracted curare with boiling alcohol, to which a few drops of soda solution had been added, evaporated off the alcohol, took up the extract with water, and, after filtration, precipitated by phosphomolybdic acid, which had been acidified with nitric acid. The precipitate was dried up with baryta water, exhausted with boiling alcohol, and curarine precipitated from the alcoholic solution by anhydrous ether. It may also be obtained by precipitating with mercuric chloride solution, and throwing out the mercury afterwards by means of hydric sulphide, &c.

Curarine, when pure, forms colourless, four-sided, very hygroscopic prisms of bitter taste, and weakly alkaline reaction; soluble in water and alcohol in all proportions, but with difficulty soluble in amyl alcohol and chloroform, and not at all in anhydrous ether, bisulphide of carbon, or benzene. The base forms crystallisable salts with hydrochloric, nitric, and acetic acids. Curarine strikes a purple colour with strong nitric acid. Concentrated solutions of curarine mixed with dilute glycerine, give an amorphous precipitate with potassic bichromate and the precipitate treated with sulphuric acid strikes a beautiful blue colour. Curarine chromate is distinguished from strychnine chromate by its amorphous character, and by its comparatively easy solubility. If the chromates of strychnine and curarine be mixed, and the mixed chromates be treated with ammonia, strychnine will be precipitated, and the curarine pass into solution, thus forming a ready method of separating them.

Physiological Effects.—According to Voisin and Liouville's experiments, subcutaneous injections of curare on man cause, in small doses, strong irritation at the place of application, swelling, and pain. The temperature of the body is raised from 1° to 2°, and the number of respirations increased from 4 to 8 per minute. The pulse becomes somewhat stronger and more powerful. The urine is increased, and contains sugar. Large doses administered to warm-blooded animals cause, after a short time, complete paralysis of voluntary motion and of reflex excitability, and the animal dies of asphyxia, the heart continuing to beat.

This state is best produced for the purpose of experiment on frogs, and, indeed, is the best test for the poison. A very minute dose injected beneath the skin of a frog soon paralyses both the voluntary and respiratory muscles; the animals continue to breathe by the skin; the heart beats normally, or, perhaps, a little weakly, and the frog may remain in this motionless condition for days, and yet recover. Only curare and its congeners have this effect. By tying the femoral artery of one of the frog's legs before administering the poison, an insight into the true action of the drug is obtained. It is then found that the reflex excitability and power of motion in the leg are retained, although all the rest of the body is paralysed. The only explanation of this is that curare does not act centrally, but paralyses the intramuscular ends of the motor nerves. Curare is eliminated partly through the liver and partly through the kidneys. Dragendorff found it in the fæces, while a striking proof that it is excreted by the kidneys is given by the experiment of Bidder,* in which the urine of a frog poisoned by curare was made to poison a second, and the urine of this second, a third. The easy excretion of curare through the kidneys furnishes explanation of the relatively large dose of curare which can be taken by the stomach without injury. A dose which, given by subcutaneous injection, would produce violent symptoms, perhaps death, may yet be swallowed, and no ill effects follow. It is hence presumed that, in the first case, the poison is, comparatively speaking, slowly absorbed, and almost as fast separated, and put, as it were, outside the body by going into the urine; while, in the other case, the whole dose is thrown suddenly into the circulation.

Separation of Curarine.—It is hardly probable that the toxicologist will have to look for curarine, unless it has entered the body by means of a wound or by subcutaneous injection; so that in all cases the absorbed poison alone must be sought for. The seat of entry, the liver, the kidneys, and the urine are the only parts likely to be of any use. Dragendorff recommends to extract the tissues with water feebly acidulated with a mineral acid, to precipitate albuminous matters, &c., by strong alcohol, and separate, by means of benzene, fatty matters. The liquid is then made alkaline, and shaken up with petroleum ether, which removes certain alkaloidal matters. It is now evaporated to dryness, mixed with finely-powdered glass, and extracted with absolute alcohol. The alcohol is evaporated to dryness, and any curarine extracted from this residue with water. By very careful drying up of this last extract, and taking it up in alcohol, the alkaloid is said to be obtained so pure as to respond to chemical tests. The identification may be by the colour reaction of sulphuric acid described *ante,* in all cases supplemented by its physiological action on frogs.*

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* *Arch. f. Anat. u. Physiol.*, 1879, p. 598.

XII.—COLCHICINE.

The whole of the *Colchicum autumnale,* or common meadow-saffron, is poisonous, owing to the presence of an alkaloid (discovered by Pelletier and Caventou) called *Colchicine.*

According to Johannson's experiments, the dried colchicum seeds contain 1·15 per cent. of colchicine; the leaves, 1·459 per cent.; the bulbs, from 1·4 to 1·58 per cent.; and the roots, 0·634 per cent. The frequent poisoning of cattle in the autumn by colchicum, its use in quack pills for rheumatism, and its supposed occasional presence in beer, give it an analytical importance.

Colchicine ($C_{17}H_{19}NO_5$) may be extracted from the seeds, &c., in the manner recommended by Hübler:—The seeds are treated, without crushing, by hot 90 per cent. alcohol, and the alcoholic solution evaporated to a syrup, which is diluted with twenty times its bulk of water and filtered; the liquid is next treated with acetate of lead, again filtered, and the lead thrown out by phosphate of soda. Colchicine is now precipitated as a tannate,* the formula of which, according to Hübler, is $3C_{17}H_{19}NO_5,2C_{27}H_{22}O_{17}$. The precipitation is best fractional, the first and last portions being rejected as containing impurities. The tannate is decomposed in the usual way with litharge, and extracted by alcohol.

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* It is known that curare may cause slight symptoms of excitation before the paralysis comes on. M. Couty has succeeded in isolating these symptoms by employing feeble extracts of strychnos triplinervia, or small doses of certain native preparations. By these means, in dogs, a new phase of intoxication may be present for ten or even twenty minutes. In the first instance the animal is agitated, jumping, scratching, barking, as if in a state of general hyperæsthesia. Then it presents half choreic shocks or tremors; the pupils dilate, and are alternately dilated and contracted. The heart's action is increased or diminished in frequency; sometimes there is vomiting, micturition, or defecation; and there is always salivation. Finally the central and peripheral temperature are raised, and the excitability of the muscles and nerves becomes highly increased. With the native preparation of curare, it is impossible to prolong this stage, and symptoms of paralysis soon become associated with those of excitement. The choreic shocks were found to be arrested by section of the sciatic nerve. Other experiments proved that the spasms originated from the spinal cord, and were influenced by its preceding functional condition. If the cord was tied in the mid-dorsal region, and the curare injected, the spasms were still produced in the hind legs; but if, after the operation, the excitability of the posterior segment became lowered, the spasm was no longer produced in the hind legs. This dependence on a perfect functional activity is a point of difference of these spasms from those produced by strychnine, and by asphyxia. The action of small doses of curare is, not, however, limited to the spinal cord. The diminished frequency of the heart continues after section of the pneumogastrics, and will even occur if the pneumogastrics have been previously divided. From these facts M. Couty considers that curare must not be regarded as entirely destitute of a "convulsivant" action, nor of an action on the central nervous system.

A simpler method is, however, extraction by chloroform from an aqueous solution, feebly acidified, as recommended by Dragendorff. The parts of the plant are digested in very dilute acid water, and the resulting solution concentrated and shaken up with chloroform, which is best done in the separating tube described and figured (p. 135).

Colchicine is usually obtained as a yellowish-white, gummy, or resinous mass; but it is also possible to obtain it in crystalline needles and prisms. It softens at 130°, and at 140° melts; it dissolves slowly but in every proportion in water; the solution is neutral. It dissolves easily in spirit. Pure colchicine is said by Hübler not to dissolve in ether—a statement contradicted by Geiger and Hesse, with whom Dragendorff agrees, and adds, that it is also soluble in benzene, amyl alcohol, and chloroform, but not in petroleum ether. Dilute acids and alkalies dissolve it, the solution becoming slowly or quickly coloured intensely yellow, whilst a decomposition takes place. Boiling with dilute acid, and also the protracted action of baryta water in closed tubes, forms *colchiceine.* Concentrated potash-lye gives, upon heating with it, a brown resinous substance.

Colchiceine crystallises in needles, or in glittering plates, and tastes less bitter than colchicine; it melts at 155°, dissolves but little in cold, copiously in boiling, water. Its difficult solubility in cold water may be taken advantage of to separate it from colchicine; according to Dragendorff, a sufficient quantity of water for this purpose must be used, since it is more soluble in solutions of colchicine than in pure water; is soluble in chloroform, methyl and ethyl alcohols, but soluble with difficulty in ether. It appears to be an acid, forming salts with the alkalies; its precipitants are—tannic acid, phosphomolybdic acid, picric acid, chloride of gold, &c.

Colchiceine gives a remarkable series of colours with the inorganic acids—a property which may be utilised as a test either for the presence of colchicine, or, conversely, for the presence of mineral acid in such liquids as vinegar, &c. Concentrated nitric acid of 1·4 specific gravity colours either colchiceine or colchicetine violet-blue, changing into yellow and lastly passing into green. If the violet solution is diluted with water it becomes yellow, and on the addition of soda, a beautiful orange-yellow or red. Concentrated sulphuric acid dissolves colchiceine with an intense yellow, and if to this solution a drop of nitric acid be added, a dark brown zone is produced, passing gradually through violet and brown into yellow.

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* The purest tannic acid must be used. The commercial tannin may be purified by evaporating to dryness with litharge, exhausting the tannate of lead repeatedly with boiling alcohol and water, and lastly, suspending in water, and separating the lead by SH_2.

The action of acids is also very distinctive, although slightly different in the case of an acid directly added to an infusion of the seeds. Thus, if a little colchicine be extracted by alcohol and water from a few grains of the seeds, and the yellowish solution diluted until the colour is scarcely perceptible, concentrated sulphuric or nitric acid gives a very pronounced yellow, which a drop of HCl changes to a blue-violet. Nitric acid dropped into another portion of the same solution concentrated, with the addition of a fragment of sodium acetate, develops an orange colour.

The precipitants of colchicine are chiefly chloride of gold and phosphomolybdic* and tannic acids. Picric acid, potassio-cadmic iodide, and potassio-hydrargyric iodide give no precipitate. Chlorine water causes, in a watery solution of colchicine, a yellow precipitate, which dissolves in ammonia with an orange colour.

Pharmaceutical Preparations.—Colchicine itself is officinal in Austria—the wine in the British, French, and Dutch, and the seeds themselves in all the pharmacopœias. The wine of colchicum, officinal in nearly all the pharmacopœias, is made with very different proportions of seeds or bulbs, as the table on next page shows.

The tincture of colchicum is officinal in our own and in all the Continental pharmacopœias; in the British, 2¼ oz. of seeds are exhausted by 20 oz. of proof spirit.

A tincture of colchicum seeds, examined by Johannson, contained ·18 per cent. of colchicine, and a tincture prepared from the bulbs ·14 per cent.

Colchicum vinegar is not officinal in Britain, but one containing 5·4 per cent. of acetic acid is so in the Netherlands, Germany, and France; the strength appears to be about ·095 per cent. of colchicine.

An extract of colchicum is officinal in Britain and France; and an acetic extract in Britain. The latter is the most active of all the pharmaceutical preparations of colchicum.

Lastly, an oxymel of colchicum is in use in Germany, France, and the Netherlands.

Quack and Patent Medicines.—In all specifics for gout the analyst will naturally search for colchicum. Most gout pills contain the ex-

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* It is useful to know that the phosphomolybdate of colchicine gives all the colour reactions of pure colchicine.

TABLE XVIII.—FORMULAS OF VARIOUS PHARMACOPŒIAS FOR COLCHICUM WINE.

	German and Norweg. Ph.	Austrian and Swiss Ph.	Netherland Ph.	British Ph.	French Ph.	
Dry Colchicum Corms,	....	....	....	....	6	6
Powdered Seeds, .	10	10	10	10 oz.	....	....
Vin. Hispanii, . .	....	...	80	....	....	....
" Malaceuse, .	....	50	....	....	....	....
" Xereuse, . .	100	....	....	9 s. ad. 50 fld. oz.	100	100
Spirit-rectifical, .	....	....	10	....	....	....

tracts ; and liquids, such as "Reynolds' gout specific," the wine or the tincture, variously flavoured and disguised.

The strength of the different pharmaceutical preparations may be ascertained by dissolving in chloroform, evaporating off the chloroform, dissolving in water (which is finally acidified by from 7 to 10 per cent. of sulphuric acid), and titrating with Mayer's reagent (see p. 234). If the solution is diluted so that there is about one part of colchicine in 600 of the solution, then each cc. of Mayer's reagent equals 31·7 mgrms. colchicine.

Fatal Dose.—In Taylor's "Principles of Medical Jurisprudence" is mentioned an instance in which 3½ drachms of colchicum wine, taken in divided doses, caused death on the fourth day. The quantity of the active principle in the colchicum wine, as found by Johannson (*Dragendorff*), being 0·18 per cent., it follows that 24·4 mgrms. (·378 grain) were fatal, though not given as one dose, so that this quantity may be considered as the least fatal one. Casper puts the lethal dose of colchicine at from 25 to 30 mgrms. (·385 to ·463 grain). It is, however, incontestable that there are cases of recovery from as much as 70 mgrms. (1·08 grain). The lethal dose of the pharmaceutical preparations of colchicum may, on these grounds, be predicted from their alkaloidal contents, and, since the latter is not constant, in any medico-legal inquiry, it may be necessary, where facility is given, to ascertain the strength of the preparation administered.

Effects of Colchicine on Animals.—The researches of Rossbach show that the carnivoræ are more sensitive to colchicine than any other class of mammals. Frogs show a transitory excitement of the nervous system, then there is loss of sensation, paralysis of motion, and of the respiratory apparatus; the heart beats after the respiration has ceased. Death follows from paralysis of the respiration. The mucous membrane of the intestine is much congested and swollen.

I have seen cattle die from the effects of eating the meadow-saffron; the animals rapidly lose condition, suffer great abdominal pain, and are generally purged. The farmers, in certain parts of the country, have had extensive losses from want of care and knowledge with regard to colchicum poisoning.

Effects of Colchicum on Man.—Colchicum poisoning in man * is not very common; F. A. Falck was able to collect from medical literature prior to 1880 fifty-five cases, and he gives the following analysis of the cases—In two, colchicum was taken for suicidal purposes; of the unintentional poisonings, five were from too large a medicinal dose of colchicum wine, syrup, or extract, given in cases of rheumatism; in thirteen cases, colchicum was used as a purgative; forty-two cases were owing to mistaking different preparations for drinks, or cordials—the tincture in five, and the wine in fourteen being taken instead of orange tincture, quinine wine, Schnapps or Madeira; in one case the corms were added to mulled wine; in another, the leaves consumed with salad; in sixteen cases (all children) the seeds of colchicum were eaten. Forty-six of the fifty-five died—that is, 83·7 per cent.

In the remarkable trial at the Central Criminal Court, in 1862, of Margaret Wilson (Reg. *v.* Marg. Wilson), who was convicted of the murder of a Mrs. Somers, the evidence given rendered it fairly probable that the prisoner had destroyed four people at different dates by colchicum. The symptoms in all four cases were—burning pain in the throat and stomach, intense thirst, violent vomiting and purging, coldness and clamminess of the skin, excessive depression, and great weakness. One victim died on the second day, another on the fifth, a third on the eighth, and the fourth on the fourteenth day. Schroff witnessed a case in which a man took 2 grms. (nearly 31 grains) of the corms; in one and a half hours he experienced general *malaise*; on the next day, there were flying muscular pains, which at length were concentrated in the diaphragm, and the breathing became oppressed; there was also pain in the neighbourhood of the duodenum, the abdomen was inflated with gas; there was a sickly feeling, and faintness. Then came on a sleepy condition, lasting several hours, followed by fever, with excessive pain in the head, noises in the ears, and delirium; there was complete recovery, but the abdomen continued painful until the fifth day.

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* For the curious epidemic of diarrhœa which broke out in the Rhone Gorge in 1875, and was referred to colchicine, see vol. i., "Foods," p. 272.

In another instance, a gentleman aged fifty,* had taken twenty-eight of Blair's gout-pills in four and a half days for the relief of a rheumatic affection. He suffered from nausea, griping pains in the belly, considerable diarrhœa, vomiting, and hiccough; towards the end there were stupor, convulsive twitchings of the muscles, paralysis, and death. The fatal illness lasted fourteen days; he was seen by three medical men at different dates; the first seems to have considered the case one of diarrhœa, the second, one of suppressed gout; but Dr. C. Budd was struck with the similarity of the symptoms to those from an acrid poison, and discovered the fact that the pills had been taken. These pills I examined; they were excessively hard, and practically consisted of nothing else than the finely-ground colchicum corms; six pills yielded 8 mgrms. of colchicine, so that the whole twenty-eight would contain 39 mgrms. ($\frac{3}{5}$ grain). Dr. Budd considered that the whole of the pills, which were of a stony hardness, remained in the bowels for some time undigested, so that the ultimate result was the same as if the whole had been taken in one dose.

The general symptoms produced by colchicum are—more or less burning pain in the whole intestinal tract, vomiting, diarrhœa, with not unfrequently bloody stools; but sometimes diarrhœa is absent. In single cases tenesmus, dysuria, and, in one case, hæmaturia have been noted. The respiration is usually troubled, the heart's action slowed, the pulse small and weak, and the temperature sinks. In a few cases there have been pains in the limbs; cerebral disturbance is rare; but in two cases (one described *ante*) there was stupor. Muscular weakness has been observed generally. In a few cases there have been cramps in the calves, and in the foot, with early collapse and death.

Post-mortem Appearances.—Schroff found in rabbits poisoned with from ·1 to 1·0 grms. of colchicine, tolerably constantly enteritis and gastritis, and always a thick, pitch-like blood in the heart and veins. Casper has carefully recorded the *post-mortem* appearances in four labourers, ages ranging from fifteen to forty years, who finding a bottle of colchicum-wine, and supposing it to be some kind of brandy, each drank a wine-glassful. They all died from its effects. In all four there was great hyperæmia of the brain membranes and of the kidneys. The large veins were filled with thick, dark, cherry-red blood, very similar to that seen in sulphuric acid poisoning. There was an acid reaction of the contents of the stomach. The lungs were moderately congested.

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* See *Lancet*, vol. i., 1881, p. 368.

The mucous membrane of the stomach of the one who died first was swollen and scarlet with congestion; with the second, there was some filling of the vessels at the small curvature; while the stomachs of the third and fourth were quite normal. In five cases described by Roux there was also hyperæmia of the brain and kidneys, but no gastritis or enteritis. It is, therefore, evident that there are in man no constant pathological changes from colchicine poisoning.

Separation of Colchicine from Organic Matters.—The solution of colchicine from the stomach, or tissues of the body, is best effected by extraction with alcohol, filtration, and concentration of the resulting filtrate by evaporation. When cool it is acidified and shaken up several times with petroleum ether, which will not dissolve the colchicine, but will remove some of the impurities. After separation of the petroleum ether, the solution is shaken up with chloroform, the latter removed in the usual way, agitated with pure water once or twice, again separated, and lastly evaporated to dryness. The colchicine, probably mixed with colchicetine, will now be in a pure enough state to admit of the successful application of tests.

In cases of poisoning by colchicum at Berlin, Wittstock used the following process:—The contents of the stomach were mixed with a large amount of alcohol, a few drops of HCl added, and the whole well shaken; the fluid was then filtered, and the filtrate evaporated to a syrupy consistence at 37°. The resulting residue was dissolved in distilled water, the fat, &c., filtered off, and the liquid carefully evaporated. From the extract foreign matter was again separated by treatment with alcohol and filtration, and the last filtrate was evaporated to a syrupy consistence. The syrupy fluid was taken up by distilled water, filtered, evaporated to 30 grms., and 2 grms. of calcined magnesia with 90 grms. of ether were added. After a time, the ether was removed, and allowed to evaporate spontaneously. The residue was once more taken up with water, filtered from fat, &c., and evaporated. This final residue gave all the reactions of colchicine. In medico-legal researches, it must be remembered that colchicine is absorbed but slowly, a not insignificant portion remaining in the bowels, with the fæces.

XIII.—MUSCARINE AND THE ACTIVE PRINCIPLES OF CERTAIN FUNGI.

The Amanita Muscaria, or fly-blown agaric, is a very conspicuous fungus, common in fir-plantations, about the size and shape of the common mushroom; but the external surface of the pileus is of a bright red, or sometimes of a yellowish cast, and studded over with warts. The common name of the fungus denotes that it was used in former times as a popular insecticide; the fungus was bruised, steeped in milk, and the milk exposed, in the same way as we now expose arsenical fly-papers.

Some peculiar properties of the agaric have long been known to the natives of Kamschatka, and of the north-eastern part of Asia generally. They collect the fungi in the hottest months, and hang them up to dry. The fungus is then rolled up in a kind of bolus, and swallowed without chewing. One large, or two small, fungi will produce a kind of intoxication, which lasts a whole day. It comes on in about two hours' time, and is very similar to that of alcohol. There is a giddy feeling, the spirits are exalted, the countenance becomes flushed, involuntary actions and words follow, and sometimes loss of consciousness. It renders some persons remarkably active, and proves highly stimulant to muscular exertion: by too large a dose violent spasmodic effects are produced. "So very exciting to the nervous system in many individuals is this fungus, that the effects are often very ludicrous. If a person under its influence wishes to step over a straw or small stick, he takes a stride or a jump sufficient to clear the trunk of a tree. A talkative person cannot keep silence or secrets, and one fond of music is perpetually singing. The most singular effect of the amanita is the influence which it has over the urine. It is said that from time immemorial the inhabitants have known that the fungus inparts an intoxicating quality to that secretion, which continues for a considerable time after taking it. For instance, a man moderately intoxicated to-day will, by the next morning, have slept himself sober, but (as is the custom) by taking a teacup of his urine he will be more powerfully intoxicated than he was the preceding day. It is, therefore, not uncommon for confirmed drunkards to preserve their urine as a precious liquor against a scarcity of the fungus. The intoxicating property of the urine is capable of being propagated; for every one who partakes of it has his urine similarly affected. Thus, with a very few amanitas, a party of drunkards may keep up their debauch for a week. Dr. Langsdorf mentions that by means of the second person taking the urine of the first, the third of the second, and so on, the intoxication may be propagated through five individuals." *

A few cases of poisoning by the fly-blown agaric from time to time have occurred in Europe, where it has been eaten in mistake for the edible fungi, or taken by children allured by the bright attractive colours. in these cases the poisonous symptoms noticed have been those of gastro-

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*Lindley's "Vegetable Kingdom."

intestinal irritation, as shown by vomiting and diarrhœa, *dilated** pupils, delirium, tetanic convulsions, slow pulse, stertorous breathing, collapse, and death. In a few cases epileptic attacks and trismus have been observed. The course is usually a rapid one, the death occurring within twelve hours. In cases of recovery, convalescence has been prolonged.

The post-mortem characteristics are not distinctive, a fluid condition of the blood, hyperæmia of the brain, liver, and kidneys has been noticed.

Muscarine.—These effects are partly due to an undiscovered, toxic substance—which seems to be destroyed at the temperature of boiling water, and is probably of rather easy destructibility—and of a very definite poisonous alkaloid (*muscarine*) first separated by a complex process, by Schmiedeberg and Koppe in 1869.† It is a trimethylammonium base, and has lately been formed synthetically by Schmiedeberg and Harnack,‡ by treating cholin with nitric acid. Muscarine is isomeric with betain and oxycholin, from which it is separated by its flourescence and poisonous properties.

Muscarine is a colourless, strongly alkaline, syrupy fluid, which, if allowed to stand over sulphuric acid, becomes gradually crystalline, but liquefies again on exposure to the atmosphere. It dissolves in water in every proportion, and also in alcohol, but is very little soluble in chloroform, and insoluble in ether. It is not precipitated by tannin ; it forms salts with acids, and gives precipitates with auric chloride, phospho-tungstic, and phosphomolybdic acids, and also with potassio-mercuric iodide. The last precipitate is at first amorphous, but it gradually becomes crystalline. This was the compound used by the discoverers to separate the base. With many other general alkaloidal reagents muscarine forms no compound that is insoluble, and therefore gives no precipitate, such, *e. g.*, as iodine with potassic iodide, picric acid, and platinic chloride. Muscarine is a stronger base than ammonia, and precipitates copper and iron oxides from solutions of their salts. Muscarine is very poisonous ; 2 to 4 mgrms. are sufficient in subcutaneous injection to kill cats in from two to twelve hours—larger doses in a few minutes ; but with rabbits the action is less intense. Cats become salivated, their pupils contract, they vomit, and are purged, the breathing becomes frequent, and there is marked dyspnœa. At a later stage the respirations are slower, and there are convulsions and death.

The alkaloid has also been tried on man. Doses of from 3 to 5 mgrms., injected subcutaneously, cause after a few minutes profuse salivation, increased frequency of the pulse, nausea, giddiness, confusion of thought and myosis, but no vomiting, and no diarrhœa. Small quantities applied to the eye cause, after a few minutes, a derangement of the accommodation, but no change in the size, of the pupil; larger quantities cause also myosis, which depends upon an excitement of the sphincter iridis, or of the oculomotorius.

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* This is the more curious, for muscarine strongly contracts the pupil. It, however, tends to prove what is stated in the text—viz., that there is more than one poisonous substance in amanita.

† *Das Muscarin, das giftige Alkaloid des Fliegenpilzes.* Leipzig, 1869.

‡ *Arch. f. Exper. Path.*, Bd., 4 u. 5

The actions of muscarine and atropine are to a great extent antagonistic. This is especially and beautifully demonstrated by the effects of the two substances on the frog's heart. The action of muscarine upon the heart is to excite the inhibitory nerve apparatus, while the action of atropine is to paralyse the same system. One mgrm. of muscarine, injected subcutaneously into a frog, arrests the heart *in diastole*, but if a suitable dose of atropine is applied to the heart thus arrested, it begins to beat again; or, if atropine is first given, and then muscarine, the heart does not stop. The muscarine heart when it has ceased to beat may be successfully stimulated by galvanism. Muscarine at first excites the respiratory centre, and then paralyses it.

Detection of Muscarine in the Body.—If muscarine itself should be ever taken, the method of detection most likely to be successful is to direct attention to the urine and kidneys, as the most suitable organs and fluids from which to separate the alkaloid. The urine should be evaporated, the residue treated with strong alcohol, and the alcoholic extract evaporated and taken up with water. This aqueous solution is now injected into frogs, and its action on the heart watched. If it stops the heart in diastole, atropine may be used to see whether the beats will be restored. The kidneys, or any other tissues of the body, must be treated on similar principles. The insolubility of muscarine in chloroform and ether renders it remarkably easy to remove fatty matters and other disturbing substances. In the present state of our knowledge, life-tests for muscarine are alone available.

The Agaricus Phalloides, with its many varieties, is a very common autumn fungus, and has often been mistaken for mushrooms. Falck has collected from medical literature no less than 53 cases of poisoning by this fungus, 40 of which ended fatally. Its chemistry is not fully worked out. Boudier considered that he had discovered an alkaloidal body, which he named *bulboisin*. Letellier and Speneux,* again, found two poisonous bodies, one an irritant, and the second a narcotic principle, which they named *amanitin*, and which seemed to be an alkaloidal substance, yielding, on treatment with saponifying agents, as one of its products, sugar. Another investigator, Ore, separated a body which he called *phalloidin;* but none of these substances have been properly studied, or, indeed, separated in a state pure enough to admit of suitable examination. The poisonous symptoms usually begin after from three to four hours, but in one case they were delayed for forty-eight hours. There is violent vomiting (in one case this symptom was absent), diarrhœa, and pain in the abdomen, which may increase so as to assume a cholera aspect, with cramps in the legs, cyanosis, and collapse. There are also nervous phenomena, convulsions, trismus, and, in a few cases, tetanic spasms. The pulse, in seven cases described by Maschka, was very small, thready, and quick, but in others, again, small and slow. The pupils have in some cases been dilated, in others unchanged. Death is generally rapid. In two of Maschka's cases from sixty to sixty-eight hours after the investigation, but in the rest from twelve to eighteen hours. Life may, however, be prolonged for several days. In a case recorded by Plowright,* in which a boy had eaten a piece of the pileus, death occurred on the fourth day.

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* *Annal. d'Hyg. Publ.*, 1867.

The post-mortem appearances observed in Maschka's seven cases were, —absence of cadaveric rigidity, dilatation of the pupil, a dark-red fluid condition of the blood, numerous ecchymoses in the pleura, in the substance of the lungs, the pericardium, the substance of the heart, the liver, kidneys, and spleen. The mucous membrane of the digestive canal presented nothing characteristic. In two cases there were a few ecchymoses, and in one the mucous membrane of the stomach was softened, red, and easily detached. In one case only were any remnants of the fungus found, by which the nature of the substance eaten could be determined. The bladder in each case was full. In three cases a fatty degeneration of the liver had commenced. The same appearance was met with in some of the older cases related by Orfila.

The Agaricus Pantherinus is said to be poisonous, although Hertwig found it to have no action when given to dogs.

The Agaricus Ruber, a bright-hued fungus, growing profusely on the Hampshire coast, of a purple-red colour—the colouring-matter not only covering the pileus, but also extending down the stipe—is poisonous, and has recently been chemically investigated by Phipson,† who has identified a colouring-matter *ruberine,* and an alkaloid, *agarythrine.* Agarythrine is separated by macerating the fungus (from which the skin containing the colouring-matter has been removed) as completely as possible in water acidulated with 8 per cent. of hydrochloric acid. The filtered solution is neutralised by sodic carbonate, and the alkaloid shaken up with ether. On evaporation the ether leaves a white, somewhat greasylooking substance, having a bitter, burning taste, and easily fusible into yellow globules, giving forth an odour like quinoleine; it is soluble in alcohol and ether. From Phipson's observations it would appear probable that the red colouring-matter is derived from a decomposition of this alkaloidal substance. A rose-red colour is produced by the action of nitric acid, and chlorinated lime first reddens and then bleaches it. Buchwald* has recorded three cases of poisoning by this fungus. The patients were labourers, who, after eating the fungus, suffered from vomiting, thirst, a "drunken" condition, cramp, albuminuria, and disturbance of the sensory functions. The fungus causes in cats myosis, but is said not to affect rabbits.

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* *Lancet,* 1879.

† *Chem. News.,* p. 199, 1882.

The Soletus Satanas, or Luridus (*Lenz*), is poisonous; very small quantities of the uncooked fungus caused in Lenz, who experimented upon its properties, violent vomiting. In cases in which this fungus has been eaten accidentally, the symptoms have been very similar to cholera.

The Common Morelle seems under certain conditions to be poisonous. From six to ten hours after the injection, there have appeared depression, nausea, jaundice, dilated pupils, and in the worst cases at the end of the first day, delirium, somnolence, and muscular cramps, followed by collapse, and death. In a case observed by Kromholz, the *post-mortem* appearances were jaundice, a dark fluid state of the blood, and hyperæmia of the brain and liver. Boström fed a dog with 100 grms. of the fresh young morelle; the animal died on the third day, and the canaliculi of the kidney were found filled with hæmoglobin partly amorphus, and partly crystalline.†

DIVISION II.—*GLUCOSIDES.*

I.—DIGITALIS GROUP.

The *Digitalis purpurea*, or foxglove, is a plant extremely common in most parts of England, and poisoning may occur from the accidental use of the root, leaves, or seeds. The seeds are very small and pitted; they weigh 1126 to a grain (*Guy*), are of a light-brown colour, and in form somewhat egg-shaped. The leaves are large, ovate, crenate, narrowed at the base, rugous, veined, and downy, especially on the under surface. Their colour is a dull green, and they have a faint odour and a bitter nauseous taste. The leaf is best examined in section. Its epidermis, when fresh, is seen to consist of transparent, hexagonal, colourless cells, beneath which, either singly or in groups, there are round cells of a magenta tint, and beneath these again a layer of columnar cells, and near the lower surface a loose parenchyma. The hairs are simple, appearing scantily on the upper, but profusely on the lower, surface; each is composed of from four to five joints or cells, and has as its base a magenta-coloured cell. The small leaves just below the seed-case, and the latter itself, are studded with glandular hairs. The root consists of numerous long slender fibres.

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* *Industr. Bl.*, 1876.

† See Casper's *Viertelj.*, 1844. Keber, *Preuss. Vereinszeitg.*, 1846. Boström, *Ber. d. Phys. Med. Soc.*, Erlangen, 1880. Schauenstein, "Giftige Schwämme" in Maschka's *Handbuch*, &c.

Chemical Composition.—It is now generally accepted that there exist in the foxglove, at least, four distinct principles—*digitalin, digitonin, digitoxin,* and *digitalein.* Besides these, there are several others of more or less definite composition, which are all closely related, and may be derived from a complex glucoside by successive removals of hydrogen in the form of water.

The following is the theoretical percentage composition of the digitalins, the identity of which has been fairly established. They are arranged according to their percentage in carbon:—

TABLE XIX.—COMPOSITION OF THE DIGITALINS.

Name.	Formula.	Percentage Composition.	
Digitalein, . . .	$C_{21}H_{46}O_{11}$	C. 53·16 per cent.	H. 8·08 per cent.
Digitonin, . . .	$C_{31}H_{52}O_{17}$	C. 53·44 ,,	H. 7·46 ,,
Digitalin, . . .	$C_{54}H_{84}O_{27}$	C. 58·16 ,,	H. 3·65 ,,
Digitaletin, . . .	$C_{44}H_{30}O_{18}$	C. 62·41 ,,	H. 3·54 ,,
Digitoxin, . . .	$C_{21}H_{32}O_{7}$	C. 63·63 ,,	H. 8·08 ,,
Digitaleretin, . . .	$C_{44}H_{28}O_{18}$	C. 66·05 ,,	H. 4·58 ,,
Paradigitaletin, . .	$C_{44}H_{34}O_{14}$	C. 67·17 ,,	H. 4·3 ,,

Digitalein is a colourless, amorphous body, easily soluble in water and in cold absolute alcohol. It may be precipitated from an alcoholic solution by the addition of much ether. It is with difficulty soluble in chloroform, and insoluble in ether. It is precipitated from a watery solution by tannin, or by basic lead acetate; saponification by dilute acids splits it up into glucose and digitaleretin. It has a sharp, acrid taste, and the watery solution froths on shaking.

Digitonin, a white amorphous body, has many of the characters of saponin. Like saponin, it is easily soluble in water, and the solution froths, and, like saponin again, it is precipitated by absolute alcohol, by baryta water, and by basic lead acetate. It may be readily distinguished from saponin by treating a watery solution with sulphuric or hydrochloric acid. On heating, a beautiful red colour develops. It does not give the bromine reaction.

Digitalin, when perfectly pure, forms fine, white, glittering, hygroscopic needles, or groups of crystalline tufts; it is without smell, but possesses a bitter taste, which is at once of slow development and of long endurance. On warming, it becomes soft under 100°, and, above that temperature, is readily decomposed with evolution of white vapours. It is insoluble in water, in dilute soda solution, in ether and in benzene. It is soluble in chloroform, especially in chloroform and alcohol, and dissolves easily in warm acetic acid; 12 parts of cold and six of boiling alcohol of 90 per cent. dissolve one of digitalin. Dilute hydrochloric or sulphuric acid decompose it into glucose and digitaletin ($C_{44}H_{30}O_{18}$); if the action is prolonged, digitaleretin ($C_{44}H_{38}O_{18}$), and finally dehydrated digitaleretin, are formed. Concentrated sulphuric acid dissolves it with the production of a green colour, which by bromine passes into violet-red, but on the addition of water becomes again green. Hydrychloric acid dissolves it with the production of a greyish-yellow colour, passing gradually into emerald green; water precipitates from this solution a resinous mass.

Digitaletin.—A substance obtained by Walz on treating his digitalin by dilute acids. It is crystalline, and its watery solution tastes bitter. It melts at 175°, and decomposes, evolving an acid vapour at about 206°. It dissolves in 848 parts of cold, and 222 of boiling, water; in 3·5 parts of cold, and in from 2 to 4 of boiling, alcohol. It is with difficulty soluble in ether. It dissolves in concentrated sulphuric acid, developing a red-brown colour, which, on the addition of water, changes to olive green. On boiling with dilute acids, it splits up into sugar and digitaleretin.

Digitoxin always accompanies digitalin in the plant, and may by suitable treatment be obtained in glittering needles and tabular crystals. It is insoluble in water and in benzene. It dissolves with some difficulty in ether, and is readily dissolved by alcohol or by chloroform. On boiling with dilute acids, it is decomposed into an amorphous, readily soluble body,—*Toxiresin.* Digitoxin, according to Schmeideberg, only exists in the leaves of the digitalis plant, and that in the proportion of 1 part in 10,000. Digitalin and digitoxin are *par excellence* the poisonous principles of the plant. Toxiresin is also intensely poisonous. It may be obtained in crystals by extracting the dry exhausted leaves with alcohol of 50 per cent., precipitating with lead acetate, and washing the precipitate first with a dilute solution of sodium carbonate (to remove colouring-matter), and then with ether, benzene, and carbon disulphide, in all of which it is insoluble; on decomposing the lead compound, digitoxin may be obtained in colourless scales or needle-shaped crystals.

Digitaleretin, the origin of which has been already alluded to, is a yellowish-white, amorphous powder, possessing no bitter taste, melting at 60°, soluble in ether or in alcohol, but insoluble in water.

Paradigitaletin is very similar to the above, but it melts at 100°, and is insoluble in ether.

Several other derivatives have been obtained and described, such as the inert *digitin*, *digitalacrin*, *digitalein*, and others, but their properties are, as yet, insufficiently studied. Digitalin, as well as digitoxin, may now be obtained pure from certain firms, but the ordinary digitalin of commerce is, for the most part, of two kinds, which may be distinguished as French and German digitalin. The French digitalin, or the digitalin of Homolle, is prepared by treating an aqueous extract of the digitalis plant with lead acetate, and freeing the filtrate from lead, lime, and magnesia, by successive additions of alkaline carbonate, oxalate, and phosphate, and then precipitating with tannin. The tannin precipitate is treated with litharge and the digitalins boiled and extracted from the mass by means of alcohol, and lastly, purifying with animal charcoal. Crystals are in this way obtained, and by removing all substances soluble in ether by that solvent, digitalin may be separated. The German digitalin is prepared according to the process of Walz, and is extracted from the plant by treatment with alcohol of ·852. The alcohol is removed by evaporation, and the alcoholic extract taken up with water; the watery extract is treated with lead acetate and litharge, filtered, the filtrate freed from lead by hydric sulphate, and the excess of acid neutralised by ammonia, and then tannin added to complete precipitation. The precipitate is collected and rubbed with hydrated oxide of lead, and the raw digitalin extracted by hot alcohol. The alcohol, on evaporation, leaves a mixture of digitalin mixed with other principles and fatty matter. If sold in this state, it may contain from 2 to 3 per cent. of digitalein and digitonins. On treating the mixture with ether, digitalin with some digitaletin is left behind, being almost insoluble in ether. Since, however, digitaletin is very insoluble in cold water, by treating the mixture with 8 parts of its weight of cold water, digitalin is dissolved out in nearly a pure state. It may be further purified by treating the solution with animal charcoal, recrystallisation from spirit, &c.

Reactions of Digitalins.—Digitonin is dissolved by dilute sulphuric acid (1 : 3) without colour, and the same remark applies to hydrochloric acid; on warming with either of these acids, a violet-red colour appears; this reaction thus serves to distinguish digitonin from the three other constituents, as well as from saponin.

Sulphuric and gallic acids colour the glucosides of digitalin, digitalein, and digitonin, red, but not digitoxin, which can be identified in this way.

Sulphuric acid and bromine give with digitalin a red, and with digitalein a violet coloration, which, on the addition of water, change respectively into emerald and light green. This, the most important chemical test we possess, is sometimes called *Grandeau's test;* it is not of great delicacy, the limit being about ·1 mgrm.

Pharmaceutical Preparations of Digitalin.—Digitalin itself is officinal in the French, British, and Austrian pharmacopœias. It is prepared in our own by making a strong tincture of the leaves at 120°F.; the spirit is then evaporated off, and the extract heated with acetic acid, decolorised by animal charcoal, and filtered. After neutralisation with ammonia, the digitalin is precipitated with tannin, and the tannate of digitalin resolved into tannate of lead and free digitalin, by rubbing it with oxide of lead and spirit.

Digitalis leaf is officinal in most of the pharmacopœias.

Tincture of digitalis is officinal in our own and all the Continental pharmacopœias, and an ethereal tincture is used in France and Germany.

An *Acetum digitalis* is officinal in the Netherlands and Germany; an extract and infusion are also used to some extent.

With regard to the nature of the active principle in these different preparations, according to Dragendorff, digitonin and digitalein are most plentiful in the acetic and aqueous preparations; whilst in the alcoholic, digitalin, digitoxin, and digitalein are present.

Fatal Dose.—The circumstances of commercial digitalin consisting of varying mixtures of digitoxin, digitalin, and digitalein, renders it difficult to be dogmatic about the dose likely to destroy life. Besides, with all heart-poisons, surprises take place; and very minute quantities have a fatal result when administered to persons with disease of the heart or to such as, owing to some constitutional peculiarity, have a heart easily affected by toxic agents. Digitoxin, according to Kopp's[*] experiments from six to ten times stronger than digitalin or digitalein. Two mgrms. caused intense poisonous symptoms. Digitoxin is contained in larger proportions in Nativelle's digitalin than in Homolle's, or in the German digitalin. The digitalin of Homolle is prescribed in 1 mgrm. (·015 grain) doses, and it is thought dangerous to exceed 6 mgrms.

Lemaistre has indeed, seen dangerous symptoms arise from 2 mgrms. (·03 grain), when administered to a boy fifteen years old. It may be predicated from recorded cases and from experiment, that digitoxin would probably be fatal to an adult man in doses of 4 mgrms. ($\frac{1}{16}$ grain), and digitalin, or digitalein, in doses of 20 mgrms. (·3 grain). With regard to commercial digitalin, as much as from 10 to 12 mgrms. (·15 to ·13 grain) have been taken without a fatal result; on the other hand, 2 mgrms. gave rise to poisonous symptoms in a woman (Battaille). Such discrepancies are to be explained on the grounds already mentioned. It is, however, probable that 4 mgrms. (or $\frac{1}{16}$ grain) of ordinary commercial digitalin would be very dangerous to an adult.

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[*] *Archiv f. Exp. Pathol. u. Pharm.* vol iii., p. 284, 1875.

It must also, in considering the dose of digitalin, be ever remembered that it is a cumulative poison, and that the same dose—harmless if taken once—yet, frequently repeated, becomes deadly: this peculiarity is shared by all poisons affecting the heart. When it is desired to settle the maximum safe dose for the various tinctures, extracts, and infusions of digitalis used in pharmacy, there is still greater difficulty, a difficulty not arising merely from the varying strength of the preparations, but also from the fact of the vomiting almost invariably excited by large doses. Individuals swallow quantities without death resulting, simply because the poison is rapidly expelled; whereas, if the œsophagus was ligatured (as in the experiments on the lower animals formerly favoured by the French school of toxicologists), death must rapidly ensue. The following table is a guide to the maximum single dose, and also the amount safe to administer in the twenty-four hours in divided doses. As a general rule, it may be laid down that double the maximum dose is likely to be dangerous:—

TABLE XX.—MAXIMUM SINGLE DOSE, AND MAXIMUM QUANTITY OF THE DIFFERENT PREPARATIONS OF DIGITALIS, WHICH CAN BE ADMINISTERED IN A DAY.

	Single Dose.		Per Day.	
	Grains or Minims.	Grammes or cc's.	Grains or Minims.	Grammes or cc's.
Powdered Leaves,	4½ grns.	3 grm.	15·4 grns.	1·0 grm.
Infusion, . .	480 m.	28.3 cc.	1440 m.	84·9 cc.
Tincture, . .	45 m.	3 cc.	135 m.	9 cc.
Digitalin, . .	·03 grn.	·002 grm.	·09 grn.	·006 grm.
Extract, . .	3·0 ,,	·2 ,,	12·0 ,,	·8 ,,

Statistics.—The main knowledge which we possess of the action of digitalis is derived from experiments on animals, and from occasional accidents in the taking of medicines; but in comparison with certain toxic agents more commonly known, the number of cases of deaths from digitalis is very insignificant. Of forty-two cases of digitalis-poisoning collected by Husemann, one was criminal (murder); one the result of mistaking the leaves for those of borage; forty-two were caused in medicinal use—in thirty-three of these last too large a dose had been given, in three the drug was used as a domestic remedy, in two of the cases the prescription was wrongly read, and in one digitalis was used as a secret remedy. Twenty-two per cent. of the forty-five were fatal.

Effects on Man.—It was first distinctly pointed out by Tardieu that toxic doses of digitalis, or its active principles, produced not only symptoms referable to an action on the heart, but also, in no small degree, gastric and intestinal irritation, similar to that induced by arsenic. Tardieu also attempted to distinguish the symptoms produced by the pharmaceutical preparations of digitalis (the tincture, extract, &c.), and the glucoside digitalin; but there does not appear a sufficient basis for this distinction. The symptoms vary in a considerable degree in different persons, and are more or less tardy or rapid in their development, according to the dose. Moderate doses continued for some time (as, for example, in the persistent use of a digitalis medicine), may produce their first toxic effects even at the end of many days; but when a single large dose is taken, the symptoms are rarely delayed more than three hours. They may commence, indeed, in half an hour, but have been known to be retarded for more than twenty-four hours; and the longer periods may be expected if digitalis is given in hard, not easily soluble pills. There is commonly a feeling of general *malaise*, and then violent retching and vomiting. The pulse at first may be accelerated, but it soon is remarkably slowed—it sinks commonly down to 50, to 40, and has even been known as low as 25. To these symptoms, referable to the heart and to the digestive tract, are added nervous troubles; there are noises in the ears, and disturbances of vision. In a case related by Taylor, a red-coal fire seemed to the patient to be of a blue colour; in another, related by Lersch,* there was blindness for eighteen hours, and for some time a confusion in the discrimination of colours; quiet delirium has also been noticed. As the case proceeds, the gastric symptoms also increase in severity; the tongue Christison, in one case, noticed to be enormously swollen, and the breath fœtid. Diarrhœa is commonly present, although also sometimes absent. The action of the kidneys is suppressed. Hiccough and convulsions close the scene.

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* *Rhen. West. Corr. Bl.*, 15, 1848. Husemann in Maschka's *Handbuch*.

In the cumulative form, the symptoms may suddenly burst out, and the person pass into death in a fainting-fit without any warning. As a rare effect, hemiplegia may be mentioned.

The brief *résumé* of the symptoms may be further illustrated by the following typical cases:—A recruit, aged 22, desiring to escape from military service, went to a so-called "*Freimacher*," who gave him 100 pills, of which he was to take eight in two doses daily. Eleven days after the use of the pills, he became ill, and was received into the hospital, where he suddenly died after three weeks' treatment. His malady was at first ascribed to gastric catarrh; for he suffered from loss of appetite, nausea, and constipation. He complained of pain in the head, and giddiness. His breath smelled badly, and the region of the stomach was painful on pressure. The pulse was slow (56), the temperature of the body normal. Towards the end, the pulse sank to 52; he suffered from vomiting, noise in the ears, troubles of vision, great weakness, and later, hiccough and swelling in the neck. The mere act of standing up in order to show his throat caused him to faint; on the same day on which this occurrence took place, he suddenly died on the way to the nightstool. Thirteen of the pills were found in the patient's clothes, and from a chemical and microscopical examination it was found that they contained digitalis leaf in fine powder. The quantity which the unfortunate man took in the four weeks was estimated at 13·7 grms. (= about 211 grains).

Two of his comrades had also been to the "*Freimacher*," and had suffered from the same symptoms, but they had left off the use of the medicine before any very serious effect was produced.* †

An instructive case of poisoning by digitoxin occurred in the person of Dr. Koppe, in the course of some experiments on the drug. He had taken 1·5 mgrm. in alcohol without result; on the following day (May 14) he took 1 mgrm. at 9 a. m., but again without appreciable symptoms. Four days later he took 2 mgrms. in alcoholic solution, and an hour afterwards felt faint and ill, with a feeling of giddiness; the pulse was irregular, of normal frequency 80 to 84. About three hours after taking the digitoxin, Dr. Koppe attempted to take a walk, but the nausea, accompanied with a feeling of weakness, became so intense that he was obliged to return to the house. Five hours after the dose, his pulse was 58, intermittent after about every 30 to 50 beats. Vomiting set in, the matters he threw up were of a dark-green colour; after vomiting he felt better for a quarter of an hour, then he again vomited much bilious matter; the pulse sank to 40, and was very intermittent, stopping after every 2 or 3 beats. Every time there was an intermission, he felt a feeling of constriction and uneasiness in the chest. Six and a quarter hours after the dose, there was again violent vomiting and retching, with paleness of the face. The muscular weakness was so great that he could not go to bed without assistance. He had a disorder of vision, so that the traits of persons well-known to him were changed, and objects had a yellow-tint. He had a sleepless night, the nausea and vomiting continuing. During the following day the symptoms were very similar, and the pulse intermittent, 54 per minute. He passed another restless night, his short sleep being disturbed by terrible dreams. On the third day he was somewhat better, the pulse was 60, but irregular and still intermittent; the nausea was also a little abated. The night was similar in its disturbed sleep to the preceding. He did not regain his full health for several days.*

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* Köhnhorn, *Vierteljhrsschr, f. Ger. Med.*, 1876, n. f. xxiv., p. 402.

† There is an interesting case on record, in which a woman died from the expressed juice of digitalis. She was twenty-seven years of age, and took a large unknown quantity of the freshly expressed juice for the purpose of relieving a swelling of the limbs. The symptoms came on almost immediately, she was very sick, and was attacked by a menorrhagia. These symptoms continued for several days with increasing severity, but it was not until the fifth day that she obtained medical assistance. She was then found semi-comatose, the face pale, pulse slow, epigastrium painful on pressure, diarrhœa, and hiccough were frequent. She died on the twelfth day. The *post-mortem* appearances showed nothing referable to digitalis save a few spots of inflammation on the stomach.—Caussé, *Bull. de Thérapeutique*, vol. lvi., p. 100; *Brit. and For. Med. Chir. Review*, vol. xxvi., 1860, p. 523.

A third case may be quoted, which differs very markedly from the preceding, and shows what a protean aspect digitalin poisoning may assume. A woman, twenty-three years old, took on June 26th, at 7 a. m., for the purpose of suicide, 16 granules of digitalin. Two hours later there was shivering and giddiness, so that she was obliged to go to bed. In the course of the day, she had hallucinations. In the evening at 8 o'clock, after eating a little food, she had a shivering-fit so violent that her teeth chattered; there was cold sweat, and difficulty in breathing; she became gradually again warm, but could not sleep. At 1 a. m. the difficulty of breathing was so great that she dragged herself to the window and there remained until 3 a. m., when she again went back to bed, slept until 7 a. m., and woke tolerably well. Since this attempt at self-destruction had failed, she took 40 granules. After one hour she became giddy, had hallucinations, chilliness, cold sweats, copious vomiting, and colicky pains; there was great muscular weakness, but no diarrhœa. Towards evening the vomiting became worse. There was no action of the bowels, nor was any urine passed; she felt as if her eyes were prominent and large. The sufferings described lasted during the whole night until five o'clock the following day, when the vomiting ceased, whilst the hallucinations, chilliness, and cold sweat continued; and the thirst, sick feeling, and weakness increased. The next morning, a physician found her motionless in bed, with pale face, notable double exophthalmus, dilated pupils, and cold skin, covered with sweat; the pulse was small and intermittent, sometimes scarcely to be felt (46 to 48 per minute); the epigastrium was painful on pressure. She passed this second night without sleep, and in the morning the pulse had risen from 56 to 58 beats, but was not quite so intermittent. There was some action of the bowels, but no urine was passed, nor had any been voided from the commencement; the bladder was not distended. The following (third) day some red-coloured, offensive urine was passed; the skin was warmer, and the pulse from 60 to 64 still somewhat intermittent—from this time she began to improve, and made a good recovery.*

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* *Arch. f. Exp. Path. u. Pharm.*, vol. iii., p. 289, 1875.

Physiological Action of the Digitalins.—Whatever other physiological action this group may have, its effects on the heart's action are so prominent and decided, that the digitalins stand as a type of *heart poisons.* The group of heart poisons has been much extended of late years, and has been found to include the following:—Antiarin, an arrow poison; helleborin, a glucoside contained in the hellebore family; a glucoside found in the *Apocynaceæ, Thevatii neriifolia,* and *Thevatia iccotli;* the poisonous principle of the *Nerium oleander* and *N. odorum;* the glucoside of *Taghinia venenifera;* convallamarin, derived from species of *convallaria;* scillotoxin, from the squill; superbin, from the Indian lily; and the alkaloid erythroephlœin from the *Erythrophlœum judiciale* (see p. 402 *et seq.*). This list is yearly increasing.

Local Action.—The digitalins have an exciting or stimulating action if applied to mucous membranes—*e. g.,* if laid upon the nasal mucous surface, sneezing is excited; if applied to the eye, there is redness of the conjunctivae with smarting; if to the tongue, there is much irritation and a bitter taste. The leaves, the extract, and the tincture have all this directly irritating action, for they all redden and inflame mucous membranes.

Action on the Heart.—The earlier experimenters on the influence of digitalis on the heart were Stannius and Traube. Stannius† experimented on cats, and found strong irregularity, and, lastly, cessation in diastole, in which state it responded no longer to stimuli. Rabbits and birds—especially those birds which lived on plants—were not so susceptible, nor were frogs.

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* Related by Ducroix: *De l'Empoisonnement par la Digitale et la Digitaline.* Paris, 1864.

† *Arch. f. Physiol.*

Traube* made his researches on dogs, using an extract, and administering doses which corresponded to from ·5 to 4·0 grms. He divided the symptoms witnessed into four stages :—

1st Stage.—The pulse frequently diminishes, while the pressure of the blood rises.

2nd Stage.—Not seen when large doses are employed ; pulse frequency, as well as blood pressure, abnormally low.

3rd Stage.—Pressure low, pulse beats above the normal frequency.

The slowing of the heart† is attributed to the stimulus of the inhibitory nerves, but the latter condition of frequency to their paralysis. After the section of the vagi the pulse frequently remains, and this is explained by the inhibitory action of the cardiac centre. The vagus, in point of time, is paralysed earlier than the muscular substance of the heart.

The increased blood pressure, Traube attributed to increased energy of the heart's contraction, through the motor-centre being stimulated later ; the commencing paralysis explains the abnormally low pressure.

There is, however, also an influence on vaso-motor nerves. What Dr. Johnson has described as the "stop-cock" action of the small arteries comes into play, the small arteries contract and attempt, as it were, to limit the supply of poisoned blood. Ackermann,‡ indeed, witnessed this phenomena in a rabbit's mesentery, distinctly seeing the arteries contract, and the blood-pressure rise after section of the spinal-cord. This observation, therefore, of Ackermann's (together with experiments of Böhm § and L. Brunton),‖ somewhat modifies Traube's explanation, and the views generally accepted respecting the cause of the increased blood-pressure may be stated thus :—The pressure is due to prolongation of the systolic stroke of the cardiac pump, and to the "stop-cock" action of the arteries ; in other words, there is an increase of force from behind (*vis a tergo*), and an increased resistance in front (*vis a fronte*).

Action of the Digitalins on the Muco-Intestinal Tract and other Organs.—In addition to that on the heart, there are other actions of the digitalins ; for example, by whatever channel the poison is introduced, vomiting has been observed. Even in frogs this, in a rudimentary manner, occurs. The diuretic action which has been noticed in man is wanting in animals, nor has a lessened diminution of urea been confirmed.

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* *Ann. d. Charité Krankenhauses*, vol. ii., p. 785.

† Slowing of the pulse was mentioned first by Withering. (*An Account of the Foxglove*, London, 1785.) Beddoes afterwards observed that digitalis increased the force of the circulation, the slowing of the pulse not being always observed ; according to Ackermann, if the inhibitory apparatus is affected by atropine, or if the patient is under deep narcosis, the slowing is absent.

‡ *Deutsch. Arch. f. Klin. Med.*, vol., xix., p. 125.

§ *Archiv. f. d. Ges. Phys.*, vol. v., p. 153.

‖ "On Digitalis, with some observations on the Urine." Lond., 1868.

Ackermann found the temperature during the period of increased blood-pressure raised superficially, but lowered internally. According to Boeck* there is no increase in the decomposition of the albuminoids.

The Action of Digitalin on the Common Blow-fly.—I have recently studied the effects of digitalin, made up into a thin paste with water, and applied to the head of the common blow-fly. There are at once great signs of irritation, the sucker is extruded to its full length, and the fly works its fore feet, attempting to brush or remove the irritating agent. The next symptom is a difficulty in walking up a perpendicular glass surface. This difficulty increases, but it is distinctly observed that weakness and paralysis occur in the legs before they are seen in the wings. Within an hour the wings become paralysed also, and the fly, if jerked from its support, falls like a stone. The insect becomes dull and motionless, and ultimately dies in from ten to twenty-four hours. I also noticed that a dose, in itself insufficient to destroy life, did so on repetition at intervals of a couple of hours. The observation is not without interest, in as much as it shows the digitalins are toxic substances to the muscular substance of even those life-forms which do not possess a heart.

Action of the Digitalins on the Frog's Heart.—The general action of the digitalins is best studied on the heart of the frog. Drs. Fagge and Stevenson have shown † that, under the influence of digitalin, there is a peculiar form of irregularity in the beats of the heart in the frog; the ventricle ultimately stops in the white contracted state, the voluntary power being retained for fifteen to twenty minutes afterwards; in very large doses there is, however, at once paralysis. Lauder Brunton ‡ considers the action of the heart to essentially consist in the prolongation of the systole.

Atropine or curare have no influence on the heart thus poisoned. If the animal under the influence of digitalin be treated with muscarine, it stops in diastole instead of systole. On the other hand, the heart poisoned by muscarine is relieved by digitalin, and a similar influence appears to be exercised by atropine. The systolic stillness of the heart is also removed by substances which paralyse the heart, as delphinin, saponin, and apomorphin.

Large doses of digitalin, thrown suddenly on the circulation by intravenous injection, cause convulsions and sudden death, from quick palsy of the heart. With frogs under these circumstances there are no convulsions, but a reflex depression, which, according to Weil, § Meihuizen,* disappears on decapitation. The central cerebral symptoms are without doubt partly due to the disturbance of the circulation, and there is good ground for attributing them also to a toxic action on the nervous substance. The arteries are affected as well as the heart, and are reduced in calibre; the blood-pressure is also increased.† This is essentially due to the firm, strong contraction of the heart, and also to the "stop-cock" action of the small arteries.‡

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* *Intoxication*, p. 404.

† *Guy's Hospl. Reports*, 3rd ver., vol. xii., p. 37.

‡ "On Digitalis, with some observations on the Urine." Lond. 1868.

§ *Archiv f. Anat. u. Pysiol.*, 1871, p. 282.

Post-mortem Appearances.—In the case of the recruit poisoned by digitalis leaf (p. 386), the blood was found dark and fluid; the right ventricle and auricle of the heart were filled with blood, the left empty; the brain and its membrane were anæmic; the stomach and mucous membrane of the intestines were in parts ecchymosed, and there were patches of injection. In the case of the widow De Pauw, poisoned with digitalin by the homœopath (Conty de la Pommerais), the only abnormality discovered were a few hyperæmic points in the mucous membrane of the stomach and small intestines. It is then certain that although more or less redness of the lining membrane of the intestine track may be present, yet, on the other hand, the active principle of the digitalis may destroy life, and leave no appreciable sign.

Separation of the Digitalins from Animal Tissues, &c.—It is best to make an alcoholic extract after the method of Stas, the alcohol being feebly acidulated by acetic acid, and all operations being carried on at a temperature below 60°. The alcoholic extract is dissolved in water feebly acidulated by acetic acid, and shaken up, first with petroleum ether to remove impurities (the ether will not dissolve any of the digitalins), then with benzene, and, lastly, with chloroform. The benzene dissolves digitalein, and the chloroform, digitalin and digitoxin. On allowing these solvents to evaporate spontaneously, residues are obtained which will give the reactions already detailed. Neither the bromine nor any other chemical test is sufficient to identify the digitalins; it is absolutely necessary to have recourse to physiological experiment. The method used by Tardieu in the classical Pommerais case may serve as a model, more especially the experiments on frogs. These frogs were properly secured, the hearts exposed, and the beats counted. The number of beats was found to be fairly equal. Frog No. 1 was placed under such conditions that the heart was constantly moist. Frog No. 2 was poisoned by injecting into the pleura 6 drops of a solution in which 10 mgrms. of digitalin were dissolved in 5 cc. of water. The third frog was poisoned by a solution of the suspected extract. The number of beats per minute were now counted at definite intervals of time as follows :—

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* *Archiv f. d. ges. Physiol.*, vol. vii., p. 201.

† The following is a brief summary of observations on the blood pressure; four stages may be noticed—(1) Rise of normal blood pressure, not necessarily accompanied with a diminution of pulse frequency; (2) continuation of heightened blood pressure, the pulse being raised beyond the normal rate; (3) continued high pressure, with great irregularity of the heart and intermittent pulse; (4) quick depression of pressure, sudden stopping of the heart, and death.

‡ According to Boehm (*Arch. f. d. Ges. Physiol.*, Bd. v., S. 189) and to Williams (*Arch. f. Exper. Pathol.*, Bd. xiii., S. 2), the rise of pressure is due entirely to the heart, and not to the contractions of the small arteries; but I fail to see how the small arteries can contract, and yet not heighten the pressure.

TABLE XXI.—ACTION OF DIGITALIN ON THE FROG'S HEART.

Frog No. 1. Unpoisoned.	Frog No. 2. Poisoned by a known quantity of digitalin.	Frog No. 3. Poisoned by the suspected extract.
No. of beats per minute.	No. of beats per minute.	No. of beats per minute.
After 6 minutes, 42	20	26
" 10 " 40	16 irregular.	24 irregular.
" 20 " 40	15	20 "
" 28 " 38	0	12 very irregular.
" 31 " 36	0	0

In operating in this way—which is strictly comparative, and, with care, has few sources of error—if the heart of the frog poisoned with the unknown extract behaves in the number and irregularity of its contractions similarly to that of the digitalin-poisoned heart, it is a fair inference that at all events a "heart-poison" has been separated ; but it is, of course, open to question whether this is a digitalin or one of the numerous groups of glucosides acting in the same way. If sufficient quantity has been separated, chemical reactions, especially the bromine test (Grandeau's test), may decide, but with the larger number (yearly increasing) of substances acting similarly on the heart, great caution in giving an opinion will be necessary.

II.—OTHER POISONOUS GLUCOSIDES ACTING ON THE HEART.

Several members of these glucosides have been recently studied by Schmiedeberg,* and his convenient divisions will be followed here :—

1. CRYSTALLISABLE GLUCOSIDES.

Antiarin $C_{14}H_{20}O_5$.—Antiarin is an arrow poison obtained from the milky juice of the *Antiaris toxicaria* growing in Java. Antiarin is obtained in crystals, by first treating the inspissated milky juice with petroleum ether to remove fatty and other matters, and then dissolving the active principle out with absolute alcohol. The alcoholic extract is taken up with water, precipitated with lead acetate, filtered, and from the filtrate antiarin obtained by freeing the solution from lead, and then evaporating. De Vry and Ludwig obtained about 4 per cent. from the juice. Antiarin is crystalline, the crystals containing 2 atoms of water. Its melting point is given as 220·6° ; the crystals are soluble in water (254 parts cold, 27·4 parts boiling), they are not soluble in benzene, and with difficulty in ether ; 1 part of antiarin requiring 2,792 parts of ether.

The watery solution is not precipitated by metallic salts. On warming with dilute mineral acids, antiarin splits up into a resin and sugar. Concentrated sulphuric acid gives with antiarin a yellow-brown solution ; hydrochloric and nitric acids strike no distinctive colours.

Effects.—Antiarin is essentially a muscular and a heart poison. When given in a sufficient dose it kills a frog in from half an hour to an hour. Its most marked effect is on the cardiac muscle, the heart beats more and more slowly, and at last stops, the ventricle being firmly contracted. As with digitalin, there is a very marked prolongation of the systole, and as with digitalin, after the beats have ceased, a forcible dilatation of the ventricle will restore them (Schmiedeberg). It is doubtful whether by physiological experiment antiarin could be differentiated from digitalin.

Separation of Antiarin.—In any case of poisoning by antiarin, it would be best to extract with alcohol, evaporate, dissolve the alcoholic extract in water, precipitate with lead acetate, filter, free the filtrate from lead, and then, after alkalising with ammonia, shake the filtrate successively with petroleum ether, benzene, and a small quantity of ether in the manner recommended at page 212, *et seq.* The liquid now freed from all fatty, resinous, and alkaloidal bodies is neutralised and evaporated to dryness in a vacuum, and dry residue taken up with absolute alcohol, filtered, the alcohol evaporated at a very low temperature, and finally the extract dissolved in a small quantity of water, and submitted to physiological tests.

The Active Principles of the Hellebores.—The Christmas rose (*Helleborus niger*) as well as *H. viridis*, *H. fœtidus*, and, in short, all the species of hellebore, are poisonous, and, if the root is treated by alcohol, from the alcoholic extract may be separated two glucosides, *helleborin* and *helleborein.*

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* *Beiträge zur Kentniss der Pharmakol. Gruppe des Digitalins.*

Helleborin is in the form of white glittering needles, which, if placed on the tongue, are almost tasteless, but if dissolved in alcohol, and then tasted, give a burning numbing sensation. By boiling with zinc chloride, helleborin splits up into sugar and a resin—*helleboresin.* Concentrated sulphuric acid dissolves the crystals with the production of a beautiful red colour; on standing the solution after a while becomes colourless, and a white powder separates.

Helleborein forms colourless crystals, mostly consisting of fine needles; they have a bitter taste, excite sneezing, and are very hygroscopic. The crystals easily dissolve in water and dilute alcohol, but are with difficulty soluble in absolute alcohol, and not soluble in ether. They dissolve in fatty oils. Helleborein splits by the action of mineral acids into sugar and amorphous *helleboretin.*

Helleboretin is in the moist condition of a beautiful violet-blue colour becoming, when dried at 100°, dirty green. Concentrated sulphuric acid dissolves it with the production of a brown-yellow colour, which on standing passes into violet and then into brown.

Marmé separated from *H. fœtidus,* in addition, a white, intensely odorous substance, but too small in quantity to thoroughly investigate its properties.

There is little doubt that hellebore owes its properties to the glucosides just described. There are several instances of poisoning by hellebore root,* and by the pharmaceutical preparations, but none of poisoning by the pure active principles. Morgagni mentions a case in which 2 grms. (nearly 31 grains) of the watery extract of *H. niger* caused death within eight hours; and Ferrari saw, after the use of the wine in which the root had been boiled, two persons poisoned with a like result. A more recent case was recorded by Felletar, in 1875, in which a person died from an infusion of hellebore; there was, however, old standing heart-disease, so that there may be a doubt as to the real cause of death in this instance. Schauenstein mentions a case in which the roots of hellebore were accidentally used in soup, but the bitter taste prevented any quantity being eaten. The physiological action, especially of helleborein, is that of an intense heart poison, and the symptoms produced by the hellebores are so strikingly like those of the digitalins that it might be difficult to distinguish clinically between them. In any case of poisoning, the active principle must be separated in the form of an alcoholic extract, and identified as a heart poison by physiological experiment.

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* There used to be a tincture officinal in our pharmacopœia; the root of *H. viridis* is officinal in the German pharmacopœia, maximum single dose, ·3 grm.; maximum total quantity in twenty-four hours, 1·2 grm. The tincture is also officinal on the Continent.

Euonymin is found in a resin obtained from the *Euonymus atropurpureus;* it is crystalline, crystallising in colourless, cauliflower-like masses consisting of groups of stellate needles, which are soluble in water, but with difficulty in alcohol. It is a glucoside and a powerful heart poison, 1 mgrm. causing the heart of a frog to cease in diastole.*

Thevetin ($C_{54}H_{48}O_{2}$).—A glucoside which has been separated from the *Thevetia nereifolia*, and perhaps also from the *Cerbera Odallam.* It is soluble in 124 parts of water at 14°, and is easily soluble in spirit, but not in ether. It is coloured by sulphuric acid red-brown, passing into cherry-red, and then, in a few hours, into violet. On boiling with diluted acids, it splits up into sugar and theveresin. Both thevetin and theveresin are powerful heart poisons.†

2. SUBSTANCES PARTLY CRYSTALLISABLE BUT WHICH ARE NOT GLUCOSIDES.

Strophantin is a very poisonous substance which belongs physiologically to this group, but does not seem to be a glucoside. It is soluble in water and in alcohol, less so in ether and chloroform. It is found in the *kombé, manganja, inée* or *onaje*, a West African poison derived from the *Strophanthus hispidus* of the family of the *apocynaceæ.* The poison has been investigated by several observers.‡

Dr. Fraser considers, from his experiments, (1) That strophantin acts primarily on the heart, producing, as an end result, heart paralysis, with permanence of the ventricular systole. (2) He found the pulmonary respiration to continue in cold-blooded animals, many minutes after the heart was paralysed. (3) The striped muscles of the body are affected, and twitches occur in them; their tonicity is exaggerated, and finally their functional activity is destroyed. This change is referred to an action on the muscular structure itself, independent of that upon the heart, and also independent of the cerebro-spinal nervous system. (4) The reflex action of the spinal cord is suspended after the heart is paralysed, but the motor conductivity of the spinal cord and of the nerve trunks continue after the striped muscles of the body are paralysed. (5) The lymph-hearts of the frog continue to contract for many minutes after the blood-heart has been paralysed.

Apocynin.—In the root of *Apocynum cannabinum* a non-crystallisable substance, soluble in alcohol and ether, but not soluble easily in water, has been separated and found to have a physiological activity similar to that of the digitalins.§

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* Schmiedeberg, *Op. cit.*, from unpublished researches of Professor H. Meyer, Dorpat.

† Husemann, *Archiv f. Exper. Path. u. Pharmakol.*, Bd. v., S. 228, 1876.

‡ *Digitoxin* (see *ante*, p. 381), belongs to this group.

§ Hardy et Callois, "*Sur la matière active du Strophanthus Hispidus ou Inée,*" *Gaz. Med. de Paris;* Pelikan, *Compt. Rend.*, t. 60, p. 1209, 1815; Sharpey, *Proc. Roy. Soc.*, May, 1865; Fagge and Stevenson, *Pharm. Journal*, p. 11, 1865–66;

3. NON-CRYSTALLISABLE GLUCOSIDES ALMOST INSOLUBLE IN WATER.

Scillain, or Scillitin, a glucoside which has been separated from the bulbs of the common squill. It is insoluble or nearly so in water, but easily dissolves in alcohol. It is little soluble in ether. It acts upon the heart, and is poisonous.

Adonidin, a very similar substance, has been separated from the root of the *Adonis vernalis* (Nat. Ord. *Ranunculaceæ*), to which the name of adonidin[*] has been given. It is an amorphous, colourless substance, without odour; soluble in alcohol, but with difficulty soluble in ether and water. It is precipitated by tannin, and on saponification by mineral acids, splits up into sugar and a substance soluble in ether. The effects on animals are identical with those of digitalin. The root has been used recently in medicine, and found to slow the heart and increase the urinary secretion; in this also it is like digitalis.

Oleandrin.—Oleander leaves contain two chemically-different, nitrogen-free substances. The one is probably identical with digitalein; but as this is not certain, Schmiedeberg proposes to call it provisionally *neriin.* The other active substance is essentially the same as the oleandrin of Lukomske[†] and Betelli.[‡] Oleandrin has basic properties, and is separated in the form of an amorphous mass, soluble in alcohol, ether, and chloroform, and slightly soluble in water. Schmiedeberg obtained a third product from African leaves, which he calls *nerianthin.* This, on treatment with sulphuric acid and bromine, gives a beautiful colour peculiar to oleander leaves. It is very similar in physiological and chemical properties to digitalin, and is probably derived by decomposition from one of the principles already described. There is also a product similar to digitaliresin.

The active principles of the oleander are separated by digestion of the leaves with alcohol of 50 per cent., and precipitating the alcoholic extract with lead acetate and ammonia. The first precipitate is yellow, and is probably composed of a tannin-like substance; the next precipitate is white, consisting of the lead compound of neriin. The precipitates are filtered off, and the filtrate concentrated; nerianthin, after a

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Fraser, *Journ. of Anatom. and Phys.*, also *Proc. of Roy. Soc. of Edin.;* Poillo and Carville, *Arch. de Physiol. Norm. et Pathol.*, 1872; G. Valentin, *Zeitschr. f. Biologie*, x. 133, 1874.

[*] Cervello, *Archiv fur Exp. Path. Pharm.*, 1882, p. 338.

[†] *Repert de Chemie de Wurtz et Bareswill,* t. iii., p. 77, 1861

[‡] *Bull. Med. di Bologna*, t. xix., p. 321, 1865.

while, separates in light flocks, and the filtrate from this contains some of the other products.

Neriin or Oleander Digitalin.—Neriin is, in the presence of much free mineral acid, precipitated by potass-bismuth iodide, a reaction first pointed out by Marmé,[*] as useful in the isolation of the helleborins; or it may be precipitated by tannin, and then the precipitate decomposed by dissolving in alcohol, and evaporating it to dryness with zinc oxide on the water bath. It is next extracted by absolute alcohol, and precipitated by the addition of much ether. The further purification consists of resolution in alcohol, and fractional precipitation by ether. If, however, the potass-bismuth iodide process is used, the liquid must be acidified strongly with sulphuric acid, and the precipitate washed with diluted sulphuric acid. The precipitate may be decomposed by baryta, filtered, and the filtrate freed from baryta by carbon dioxide; the filtrate from this contains neriin with baric iodide; it is, therefore, treated with silver sulphate, then again with baryta, next with carbon dioxide, and also with SH_2 to get rid of the last trace of silver.

The filtrate will also contain some oleandrin, which, by evaporating slowly in a vacuum, separates gradually in the form of a clear, resinous mass. It can be filtered off, and the neriin then may be precipitated pure by fractional precipitation. Its physiological action is the same as that of digitalein.

The nerium oleander has several times caused grave symptoms of poisoning, and they have usually fairly agreed with those produced by foxglove. For example, Maschka[†] relates the case of a boy, two years old, who ate two handfuls of the nerium oleander. The effects commenced in ten minutes, the child was uneasy, and vomited. In six hours a sleepy condition came on; the face was pale, the skin cold, the pupils contracted, and the pulse slow and irregular. After the sickness the boy woke up, but again fell asleep, and this occurred frequently; coffee was given, which appeared to do good. The pulse was intermittent. On the following day the child was still ill, with an intermittent pulse, frequent vomiting, feebleness, sleeplessness, and dilatation of the pupil; there was no diarrhœa; on the contrary, the bowels were confined. On the third day recovery followed.

In an Indian case,[‡] the symptoms were altogether peculiar, and belonged rather to the convulsive order. A wood-cutter, aged thirty-five, near Kholapore, took, for the purpose of suicide, a little over an ounce of the expressed juice of the oleander. The symptoms began so rapidly that he had not time to walk five yards before he fell insensible; he was brought to the hospital in this state; the face on his arrival was noticed to be flushed, the breathing stertorous; there were violent spasmodic contractions of the whole body, more marked on the left than on the right side. The effect of this was remarkable. During the intervals of the spasm, the patient lay evenly on his back, and when the convulsion commenced the superior contraction of the left side threw him on the right, in which position he remained during the paroxysm, after the subsidence of which he fell back into his old position. The evacuations were involuntary and watery; the man was insensible, with frequent convulsions of the kind described, for two days, but on the third day became conscious, and made a good recovery.

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[*] *Zeitschr. f. Rat. Med.* [3 R.], Bd. xxvi., S. 1, 1866.

[†] *Vierteljahrsschrift*, Bd. ii., No. 17, 1860. *Brit. and For. Med. Chir. Review*, vol. xxvi., p. 523, 1860.

[‡] *Transac. of Med. and Phys. Soc. of Bombay*, 1859.

In any case of poisoning, the methods by which nerium and oleandrin are separated from the plant can be applied to separate them from the tissues with more or less success. Here, as in all the other digitalin-like glucosides, physiological tests are alone of value in the final identification.

The Madagascar Ordeal Poison.—To this group may also belong the poison of the *Tauchinia venenifera*, a tree in the Island of Madagascar, the fruit of which is used as an ordeal poison. It may be obtained in crystals, it is insoluble in water, and very poisonous. The upas of Singapore is also said to contain with strychnine a glucoside similar to antiarin.

4. SUBSTANCES WHICH, WITH OTHER TOXIC EFFECTS, BEHAVE LIKE THE DIGITALINS.

Erythrophlein is an alkaloid, not a glucoside, and is obtained from the bark of the *Erythrophlœum guineense* (West Africa). It acts on the heart like digitalis, and has also effects similar to picrotoxin.

III.—SAPONIN.

Saponin ($C_{32}H_{54}O_{18}$) is a glucoside, which, in an impure state, has been known under various names, such as struthin, quillajin, senigin, polygalin, cithagin, monninin, and monesia, names suggested by the respective plants yielding the principle.

Saponin was first discovered by Schrader in the root of *Saponaria officinalis*, but it has since been found in a variety of other plants, more especially in those belonging to the natural order of clove-worts (*Caryophyllaceæ*). A few of the plants known to yield saponin by appropriate treatment are as follows:—*Gypsophila Struthium*, *Agrostemma Githago* (corn-cockle), *Polygala Senega*, *Monnina polystachia*, the bark of the *Quillaja saponaria*, and the *Chrysophyllum glycyphlæum*.

Saponin is an undoubted poison, and it may be of considerable importance to the chemical expert to be acquainted with the best methods of extracting it from organic substances, since it is occasionally conveyed into flour by accident, the seeds of the common corn-cockle being ground up with the wheat. The corn-cockle contains a notable proportion of saponin (see vol. i. "Foods," p. 153). It is not impossible that some of the mysterious cases of poisoning which have occurred from time to time after eating buns, cakes, or bread, have been caused by this agent, for saponin would be overlooked by routine and ordinary methods of toxicological research.

Properties.—Saponin is a white amorphous powder, very soluble in water, to which it gives the curious property of frothing just like soap solution. To obtain this effect there must be at least 1 mgrm. in 1 cc. of liquid. Saponin is neutral in reaction, it has no odour, but causes sneezing if applied to the mucous membrane of the nose; the taste is at first sweet, and then sharp and acrid. It is almost entirely insoluble in absolute alcohol, but dissolves in hot alcohol of 83° to separate again nearly completely on cooling. It is precipitated by basic lead acetate, and also by baryta water, but in each case it is advisable to operate on concentrated solutions. Picric acid, mercuric chloride, and alkaloidal "group reagents" give no precipitate. When a little of the solid substance is treated with "Nessler" reagent, there is a greenish or yellow colour produced. A drop of strong sulphuric acid, mixed with a minute quantity of saponin, strikes slowly a bright red colour, which, on heating, deepens to maroon-brown. Nordhausen sulphuric acid shows this better and more rapidly. If saponin is boiled with dilute acid it breaks up into sapogenin and sugar, and therefore the liquid after neutralisation reduces "Fehling." This reaction is after the following equation:—

$$\underset{\text{Saponin.}}{C_{32}H_{54}O_{18}}+2H_2O=\underset{\text{Sapogenin.}}{C_{14}H_{22}O_2}+\underset{\text{Sugar.}}{3O_6H_{12}O_6}.$$

Sapogenin may be separated by evaporating the neutralised liquid to dryness, treating the dry residue with ether, which dissolves out the sapogenin, and finally recovering the substance from the ethereal solution, and crystallising it from hot alcohol. Crystals are readily obtained if the alcoholic solution is allowed to evaporate spontaneously. A solution of saponin exposed to the air gets turbid, and develops carbon dioxide; not unfrequently the solution becomes mouldy.

Effects.—Pelikan* has studied the effects of various saponins on frogs. One to two drops of a saturated watery solution of saponin applied subcutaneously to the leg, caused, in from 5 to 6 minutes, great weakness, accompanied by a loss of sensibility; but strong mechanical, chemical, or electrical stimuli applied to the foot excited reflex action, for the ischiatic nerve still retained its functions. Nevertheless, from the commencement, the excitability of the poisoned muscles was much weakened, and just before death quite disappeared. Section of the ischiatic nerve delayed the phenomena. Curarine did not seem to have any effect on the poisonous action. A concentrated solution applied to the heart of a frog soon arrests its beats, but weaker doses first excite, and then retard.*

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* *Berl. Kl. Wochscher.*, 36, 186.

I have recently studied the general action of saponin on kittens, insects, and infusoria. Small doses, such as from 13 to 32 mgrms. ($\frac{1}{5}$ to ½ grain), were injected beneath the loose skin at the back of the neck of a kitten, when there were immediate symptoms of local pain. In from 5 to 10 minutes the respiration notably quickened, and the animal fell into a lethargic state, with signs of general muscular weakness; just before death the breathing became very rapid, and there were all the signs of asphyxia. The pathological appearances after death were fulness in the right side of the heart, and intense congestion of the intestinal canal, the stomach generally being perfectly normal in appearance, and the kidneys and other organs healthy. The least fatal dose for a kitten seems to be 13 mgrms., or ·04 grm. to a kilogram.†

Action on Man.—The effects of saponin on man have been but little studied; it has been administered by the mouth in doses of from ·1 to ·2 grm., and in those doses seems to have distinct physiological effects. There is increased mucous secretion, and a feeling of nausea; but neither diaphoresis nor diuresis has been observed. From the foregoing study it may be predicated that 2·6 grms. (40 grains), if administered subcutaneously to an adult, would endanger life. The symptoms would be great muscular prostration, weakness of the heart's action, and probably diarrhœa. In fatal cases, some signs of an irritant or inflammatory action on the mucous membranes of the stomach and intestines would be probable.

Separation of Saponin.—Saponin is separated from bread, flour, and similar substances by the process given at p. 153, "Foods, vol. i. The process essentially consists in extracting with hot spirit, allowing the saponin to separate as the spirit cools, collecting the precipitate on a filter, drying, dissolving in cold water, and precipitating with absolute alcohol. In operating on animal tissues, a more elaborate process is necessary. I have successfully proceeded as follows:—The finely divided organ is digested in alcohol of 80 to 90 per cent. strength, and boiled for a quarter of an hour; the alcohol is filtered hot and allowed to cool, when a deposit forms, consisting of fatty matters, and containing any saponin present. The deposit is filtered off, dried, and treated with ether to remove fat. The insoluble saponin remaining is dissolved in the least possible quantity of water, and precipitated with absolute alcohol. It is also open to the analyst to purify it by precipitating with baryta water, the baryta compound being subsequently decomposed by carbon dioxide. Basic lead acetate may also be used as a precipitant, the lead compound being as usual decomposed by hydric sulphide; lastly, a watery solution may be shaken up with chloroform, which will extract saponin. By some of these methods selected, according to the exigencies of the case, there will be no difficulty in separating the glucoside in a fairly pure state. The organ best to examine for saponin is the kidney. In one of my own experiments, in a cat poisoned with a subcutaneous dose of saponin (·2 grm.), evidence of the glucoside was obtained from the kidney alone. The time after death at which it is probable that saponin could be detected is unknown; it is a substance easily decomposed, and, therefore, success in separating it from highly putrid matters is not probable.

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* J. Hoppe, *Nervenwirkung der Heilmittel*, H. 4, 37.

† The action of saponin when applied in concentrated solution to flies is that of an intense irritant. There is protrusion of the sucker, and progressive paralysis. The common infusoria live for some time in dilute solutions of saponin—this is also true of some of the higher forms; for example, a *Cylcops quadricornis* seemed in no way affected by a 2 per cent. solution.

Identification of Saponin.—An amorphous white powder, very soluble in water, insoluble in cold alcohol or ether, having glucosidal reactions, striking a red colour with sulphuric acid, imparting a soap-like condition to water, and poisonous to animals, can be no other than saponin.

DIVISION III.—CERTAIN POISONOUS ANHYDRIDES OF ORGANIC ACIDS.

I.—SANTONIN.

Santonin ($C_{15}H_{18}O_3$) is a neutral principle extracted from the unexpanded heads of various species of *artemisia* (Nat. Ord *compositæ*). The seeds contain, according to Dragendorff, 2·03 to 2·13 per cent. of santonin, and about 2·25 per cent. of volatile oil with 3 per cent. of fat and resin. Santonin forms brilliant, white, four-sided, flat prisms, in taste feebly bitter. The crystals become yellow through age and exposure to light; they melt at 169°, and are capable of being sublimed; they are scarcely soluble in cold water, but dissolve in 250 parts of boiling water, freely in alkaline water, in 3 parts of boiling alcohol, and in 42 parts of boiling ether. Santonin is the anhydride of santonic acid ($C_{15}H_{20}O_4$). Santonin unites with alkalies to form santonates. Sodic santonate ($C_{15}H_{19}NaO_4 + 3\frac{1}{2} H_2O$) is officinal on the Continent; it forms colourless rhombic crystals, soluble in 3 parts of cold water.

Poisoning by Santonin—Eighteen cases of poisoning, either by santonin or santonin-holding substances, which F. A. Falck has been able to collect, were nearly all occasioned by its use as a remedy for worms. A few were poisonings of children who had swallowed it by accident. With one exception those poisoned were children of from two to twelve years of age; in five the flower-heads, and in thirteen santonin itself was taken. Of the eighteen cases, only two died (about 11 per cent.)

Fatal Dose.—So small a number of children have died from santonin that data are not present for fixing the minimum fatal dose. ·12 grm. of santonin killed a boy of five and a half years of age in fifteen hours; a girl, ten years old, died from a quantity of flower-heads equal to ·2 grm. of santonin. The maximum dose for children is from 65 to 194 mgrms. (1 to 3 grains), and twice the quantity for adults.

Effects on Animals.—Experiments on animals with santonin have been numerous. It has first an exciting action on the centres of nerves from the second to the seventh pairs, and then follows decrease of excitability. The medulla is later affected. There are tetanic convulsions, and death follows through asphyxia. Artificial respiration lessens the number and activity of the convulsions, and chloroform, chloral hydrate, or ether, also either prevent or shorten the attacks.

Effects on Man.—One of the most constant effects of santonin is a peculiar aberration of the colour-sense, first observed by Hufeland in 1806. All things seem yellow, and this may last for twenty-four hours, seldom longer. According to Rose, this apparent yellowness is often preceded by a violet hue over all objects. If the lids are closed while the "yellow sight" is present, the whole field is momentarily violet. De Martiny* in a few cases found the "yellow sight" intermit and pass into other colours—*e. g.*, after ·3 grm. there was first the yellow perception, then giving the same individual ·6 grm., all objects seemed coloured red, after half an hour orange, and then again yellow. In another patient the effect of the drug was to give "green vision," and in a third blue.

Hufner and Helmholtz explain this curious effect as a direct action on the nervous elements of the retina, causing them to give the perception of violet; they are first excited, then exhausted, and the eye is "violet blind." On the other hand, it has been suggested that santonin either colours the media of the eye yellow, or that there is an increase in the pigment of the *macula lutea.* I, however, cannot comprehend how the two last theories will account for the intermittency and the play of colours observed in a few cases. To the affections of vision are also often added hallucinations of taste and smell; there is headache and giddiness, and in fourteen out of thirty of Rose's observations vomiting occurred. The urinary secretion is increased. In large and fatal doses there are shivering of the body, clonic and often tetanic convulsions; the consciousness is lost, the skin is cool, but covered with sweat, the pupils dilated, the breathing becomes stertorous, the heart's action weak and slow and death occurs in collapse—in the case observed by Grimm in fifteen hours, in one observed by Linstow in forty-eight hours. In those patients who have recovered, there has also been noticed convulsions and loss of consciousness. Sieveking * has recorded the case of a child who took ·12 grm. (1·7 grains) santonin; an eruption of nettle rash showed itself, but disappeared within an hour.

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* *Gaz. des Hôspit.*, 1860.

Post-mortem Appearances.—The *post-mortem* appearances are not characteristic.

Separation of Santonin from the Contents of the Stomach, &c.—It is specially important to analyze the fæces, for it has been observed that some portion goes unchanged into the intestinal canal. The urine, also, of persons who have taken santonin, possesses some important peculiarities. It becomes of a peculiar yellow-green, the colour appearing soon after the ingestion of the drug, and lasting even sixty hours. The colour may be imitated, and therefore confused with that which is produced by the bile acids; a similar colour is also seen after persons have been taking rhubarb. Alkalies added to urine coloured by santonin or rhubarb strike a red colour. If the urine thus reddened is digested on zinc dust, santonin urine fades, rhubarb urine remains red. Further, if the reddened urine is precipitated by excess of milk of lime or baryta water and filtered, the filtrate from the urine reddened by rhubarb is colourless, in that reddened by santonin the colour remains. Santonin may be isolated by treating substances containing it with warm alkaline water. The water may now be acidified and shaken up with chloroform, which will dissolve out any santonin. On driving off the chloroform the residue should be again alkalised, dissolved in water, and acidified with hydrochloric acid, and shaken up with chloroform. On this way, by operating several times, it may be obtained very pure. Santonin may be identified by its dissolving in alcoholic potash to a transitory carmine-red, but the best reaction is to dissolve it in concentrated sulphuric acid, to which a very little water has been added, to warm on the water bath, and then to add a few drops of ferric chloride solution in the warm acid; a ring of a beautiful red colour passing into purple surrounds each drop, and after a little time, on continuing the heat, the purple passes into brown.

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* *Brit. Med. Journ.*, 1871.

II.—MEZEREON.

The Daphne Mezereum (L.)—Mezereon, an indigenous shrub belonging to the *Thymeleaceæ*, is rather rare in the wild state, but very frequent in gardens. The flowers are purple and the berries red. Buckheim isolated by means of ether an acrid resin, which was converted by saponifying agents into *mezereic acid;* the acrid resin is the anhydride of the acid. The resin is presumed to be the active poisonous constituent of the plant, but the subject awaits further investigation. There are a few cases of poisoning on record, and they have been mostly from the berries. Thus, Linné has recorded an instance in which a little girl died after eating twelve berries. The symptoms observed in the recorded cases have been burning in the mouth, gastro-enteritis, vomiting, giddiness, narcosis, and convulsions, ending in death.

DIVISION IV.—VARIOUS VEGETABLE POISONOUS PRINCIPLES—NOT ADMITTING OF CLASSIFICATION UNDER THE PREVIOUS THREE DIVISIONS.

I.—ERGOT OF RYE.

Ergot is a peculiar fungus attacking the rye and other graminaceous plants;* it has received various names, *Claviceps purpurea* (Tulasne), *Spermœdia clavus* (Fries), *Sclerotium clavus,* (D.C.) &c. The peculiar train of symptoms arising from the eating of ergotised grain (culminating occasionally in gangrene of the lower limbs), its powerful action on the pregnant uterus, and its styptic effects, are well known.

The general use of the drug by accoucheurs has, so to speak, popularised a knowledge of its action among all classes of society, and its criminal employment as an abortive appears to be on the increase.*

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* Some of the *Cyperaceæ* are also attacked.

The healthy grain of rye, if examined microscopically in thin sections, is seen to be composed of the seed-coating, made up of two layers, beneath which are the gluten-cells, whilst the great bulk of the seed is composed of cells containing starch. In the ergotised grain, dark (almost black) cells replace the seed-coat and the gluten-cells, whilst the large starch-containing cells are filled with the small cells of the fungus and numerous drops of oil.

The Chemical Constituents of Ergot are a fixed oil, trimethylamine, certain active principles, and colouring-matters.

The *fixed oil* is of a brownish-yellow colour, of aromatic flavour and acrid taste; its specific gravity is 0·924, and it consists chiefly of palmitin and olein; it has no physiological action.

Trimethylamine is always present ready formed in ergot; it can also be produced by the action of the potash on ergot.

With regard to the *active principles of ergot* considerable confusion still exists, and no one has hitherto isolated any single substance in such a state of purity as to inspire confidence as to its formula or other chemical characters. They may be, however, briefly described.

C. Tamet† has separated an alkaloid, which appears identical with Wenzel's *ergotinine*. To obtain this the ergot is extracted by alcohol of 86°, the spirit removed by distillation, and the residue cooled; a resin (which is deposited) and a fatty layer (which floats on the surface) are separated from the extractive liquor and washed with ether; the ethereal solution is filtered and shaken with dilute sulphuric acid, which takes up the alkaloid; the aqueous solution of the sulphate is then filtered, rendered alkaline by KHO, and agitated with chloroform. The ergotinine is now obtained by evaporating the chloroform solution, care being taken to protect it from contact with the air. It gives precipitates with chloride of gold, potassium iodohydrargyrate, phospho-molybdic acid, tannin, bromine water, and the chlorides of gold and platinum. With moderately concentrated SO_4H_2, it gives a yellowish-red coloration, changing to an intense violet, a reaction which does not occur if the alkaloid has been exposed to the air. The composition of the base is represented by the formula $C_{70}H_{40}N_4O_{12}$, and a crystalline sulphate and lactate have been obtained.‡

Wenzel's *Ecboline* is prepared by precipitating the cold watery extract of ergot with sugar of lead, throwing out the lead in the usual way by hydric sulphide, concentrating the liquid, and adding mercuric chloride, which precipitates only the ecboline. The mercury salt is now decomposed with hydric sulphide, and after the mercury precipitate has been filtered off, the filtrate is treated with freshly precipitated phosphate of silver, and refiltered ; lastly, the liquid is shaken up with milk of lime, again filtered, and the lime thrown out by CO_2. The last filtrate contains ecboline only, and is obtained by evaporation at a gentle heat. It is an amorphous, feebly bitter substance, with an alkaline reaction, forming only amorphous salts.

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* The Russian peasantry use the drug for the same purpose. *Vide* Mackenzie Wallace's "Russia," i., p. 117.

† *Compt. Rendus*, vol. xxxi., p. 896.

‡ *Compt. Rendus*, April, 1878.

The most recent research by Dragendorff on ergot tends to show that Wenzel's alkaloids, ergotinine and ecboline, are inactive. Dragendorff describes also (*a.*) *Scleromucin,* a slimy substance which goes into solution upon extraction of the ergot with water, and which is again precipitated by 40 to 45 per cent. alcohol. It is colloidal and soluble with difficulty in water. It contains nitrogen, but gives no albuminoid reaction, nor any reaction of an alkaloidal or glucosidal body ; it yields to analysis—

8·26	per cent.	Water.
26·8	,,	Ash.
39·0	,,	Carbon.
6·44	,,	Hydrogen.
6·41	,,	Nitrogen.

(*b.*) *Sclerotic Acid.*—A feebly-acid substance, easily soluble in water and dilute and moderately concentrated alcohol. It passes, in association with other constituents of the ergot extract, into the diffusate, when the extract is submitted to dialysis ; but after its separation in a pure state it is, like scleromucin, colloidal. It is precipitated by 85 to 90 per cent. alcohol, together with lime, potash, soda, silica, and manganese, but after maceration, with hydrochloric acid, the greater part of the ash constituents can be separated by a fresh precipitation with absolute alcohol. The sample gave 40·0 per cent. of carbon, 5·2 per cent. hydrogen, 4·2 per cent. nitrogen, 50·6 per cent. oxygen, with 3·4 per cent. of ash. Sclerotic acid forms with lime a compound that is not decomposed by carbonic acid, and which upon combustion leaves from 19 to 20 per cent. of calcium carbonate. Both these substances are active, although evidently impure. Sclerotic acid is sold in commerce, and has been employed subcutaneously in midwifery practice in Russia and Germany for some time.

The inert principles of ergot are : (1) A red colouring matter, *Sclererythrin,* insoluble in water, but soluble in dilute and strong alcohol, ether, chloroform, dilute solutions of potash, ammonia, &c. It can be obtained by dissolving in an alkali, neutralising with an acid, and shaking up with ether. Alcoholic solution of sclererythrin gives with aluminum sulphate, and with zinc chloride, a splendid red mixture; with salts of calcium, barium, and many of the heavy metals, it gives a blue precipitate; the yield is only ·1 to ·05 in a thousand parts.

(2.) Another colouring matter, dissolving in concentrated sulphuric acid with the production of a fine blue violet colour, the discoverer has named *Scleroidin*. This is not soluble in alcohol, ether, chloroform, or water, but dissolves in alkaline solutions, potash producing a splendid violet colour; yield about 1 per 1000.

(3, 4.) Two crystalline substances, which may be obtained from ergot powder, first treated with an aqueous solution of tartaric acid, and the colouring-matters extracted by ether. One Dragendorff names *Sclerocrystallin* ($C_{10}H_{10}O_4$); it is in colourless needles, insoluble in alcohol and water, with difficulty soluble in ether, but dissolving in ammonia and potash solutions. The other crystalline substance is thought to be merely a hydrated compound of sclerocrystallin. Both are without physiological action.

Detection of Ergot in Flour (see vol. i. "Foods," p. 154).—The best process is to exhaust the flour with boiling alcohol. The alcoholic solution is acidified with dilute sulphuric acid, and the coloured liquid examined by the spectroscope in thicker or thinner layers, according to the depth of colour. A similar alcoholic solution of ergot should be made, and the spectrum compared. If the flour is ergotised the solution will be more or less red, and show two absorption bands, one in the green, and a broader and stronger one in the blue. On mixing the original solution with twice its volume of water, and shaking successive portions of this liquid with ether, amyl alcohol, benzene, and chloroform, the red colour, if derived from ergot, will impart its colour to each and all of these solvents.

Pharmaceutical Preparations.—Ergot itself is officinal in all the pharmacopœias, and occurs in grains from ⅓ to 1 inch in length, and about the same in breadth, triangular, curved, obtuse at the ends, of a purple colour, covered with a bloom, and brittle, exhibiting a pinkish interior, and the microscopical appearances already detailed. Ergot may also occur as a brown powder, possessing the unmistakable odour of the drug. A liquid extract of the B.P. is prepared by exhausting the ergot of fat by ether, digesting the marc in water at 160°F., and evaporating; spirit is then added, and the liquid filtered from the precipitate which is formed. The extract of the Continental pharmacopœias is very similar. It has been found in practice that the addition of a little sulphuric acid aids in preserving the strength of the extract, which will, therefore, be generally found acid, containing from 12 to 14 per cent. of solid matters, and yielding from ·022 to ·028 of the albuminoid nitrogen when distilled with alkaline permanganate of potash. A tincture and an infusion are also officinal; the latter is very frequently used, but seldom sold, for it is preferable to prepare it on the spot. The tincture experience has shown to be far inferior in power to the extract, and it is not much used.

Dose.—The main difficulties in the statement of the medicinal dose, and of the minimum quantity which will destroy life, are the extreme variability of different samples of ergot and its readiness to decompose. A full medicinal dose of ergot itself, as given to a woman in labour, is 4 grms. (61·7 grains), repeated every half hour. In this way enormous doses may be given in some cases without much effect. On the other hand, single doses of from 1 to 4 grms. have caused serious poisonous symptoms. The extract and the tincture are seldom given in larger doses than that of a drachm as a first dose, to excite uterine contraction. In fact, the medical practitioner has in many cases to experiment on his patient with the drug, in order to discover not only the individual susceptibility, but the activity of the particular preparation used. From the experiments of Nikitin, it is probable that the least fatal dose of sclerotic acid for an adult man is 20 mgrms. per kilogrm.

Ergotism.—Ergotised cereals have played a great part in various epidemics, probably from very early times, but the only accurate records respecting them date from the sixteenth century. According to Dr. Tissot,* the first recorded epidemic was in 1596, when a strange, spasmodic, convulsive disease broke out in Hessia and the neighbouring regions. It was probably due to spurred rye. In Voigtlander, the same disease appeared in 1648, 1649, and 1675; in 1702 the whole of Freiberg was attacked. In Germany and in France successive epidemics are described throughout the 18th century. In France, in 1710, Ch. Noel, physician at the *Hotel Dieu*, had no less than fifty cases under treatment at the same time.

It is generally said that in 1630, Thuillier, in describing an ergot epidemic which broke out in Cologne, first referred the cause of the disease to spurred rye.

It is interesting to inquire into the mortality from this disease. In 1770, in an epidemic described by Taube, in which 600 were affected, 16 per cent. died. In a nineteenth-century epidemic (1855), in which, according to Husemann, 30 were ill; 23·3 per cent. died. In other epidemics, according to Heusinger, out of 102, 12 per cent. died; according to Griepenkerl, out of 155, 25 or 16 per cent. died; and, according to Meyer, of 283 cases, 6 per cent. died.

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* Dr. Tissot in *Phil. Trans.*, vol. lv., p. 106, 1765. This is a Latin letter by Dr. Baker, and gives a good history of the various epidemics of ergotism.

There are two forms of chronic poisoning by ergot—one a spasmodic form, the other the gangrenous form.

The Convulsive Form of Ergotism mostly begins with some celebral disturbance. There are sparks before the eyes, giddiness, noises in the ears, and a creeping feeling about the body. There is also very commonly anæsthesia of the fingers and toes, and later of the extremities, of the back, and even of the tongue. Diarrhœa, vomiting, colic, and other signs of intestinal irritation seldom fail to be present; there are also tetanic spasms of the muscles, rising in some cases to well-marked tetanus; epilepsy, faintings, aberrations of vision, amaurosis, and amblyopia are frequent; the skin becomes of a yellow or earthly colour, and is covered with a cold sweat; boils and other eruptions may break out; blebs, like those caused by burns or scalds, have in a few cases been noticed. Death may occur in from 4 to 12 weeks after the eating of the spurred grain from exhaustion. In those individuals who recover, there remain for some time weakness, contractions of groups of muscles, anæmia, or affections of vision.

The Gangrenous Form of Ergotism.—In this form there is generally acute pain in the limb or limbs which are to mortify; and there may be prodromata, similar to those already described. The limb swells, is covered with an erysipelatous blush, but at the same time feels icy cold; the gangrene is generally dry, occasionally moist; the mummified parts separate from the healthy by a moist ulcerative process; and in this way the toes, fingers, legs, and even the nose, may be lost. During the process of separation there is some fever, and pyæmia may occur with a fatal result.

Fontenelle described a case in which a rustic lost all the toes of one foot, then those of the other; after that, the remnant of the first foot, and lastly the leg. But probably the most extraordinary case of gangrene caused by the use of ergot is that which occurred at Wattisham, Suffolk, in the family of a labouring man named John Downing. He had a wife and six children of various ages, from fifteen years to four months. On Monday, January 10th, 1762, the eldest girl complained of a pain in the calf of her left leg; in the evening her sister, aged ten, also experienced the same symptoms. On the following Monday, the mother and another child, and on Tuesday all the rest of the family except the father become affected. The pain was very violent. The baby at the breast lived a few weeks, and died of mortification of the extremities. The limbs of the family now began to slough off, and the following are the notes on their condition made by an observer, Dr. C. Wollaston, F.R.S., on April 13:—

"The mother, aged 40. Right foot off at the ankle, the left leg mortified; a mere bone left, but not off.

Elizabeth, aged 13. Both legs off below the knees.
Sarah, aged 10. One foot off at the ankle.
Robert, aged 8. Both legs off below the knees.
Richard, aged 4. Both feet off at the ankle.
Infant, four months old, dead."

The father was also attacked a fortnight after the rest of the family, and in a slighter degree—the pain being confined to the fingers of his right hand, which turned a blackish colour, and were withered for some time, but ultimately got better.

As a remarkable fact, it is specially noted that the family were in other respects well. They ate heartily, and slept soundly when the pain began to abate. The mother looked emaciated. "The poor boy in particular looked as healthy and florid as possible, and was sitting on the bed, quite jolly, drumming with his stumps." They lived, as the country people at that time usually lived, on dried peas, pickled pork, bread and cheese, milk, and small beer. Dr. Wollaston strictly examined the corn with which they made their bread, and he found it "very bad; it was wheat that had been cut in a rainy season, and had lain in the ground till many of the grains were black and totally decayed." *

Symptoms of Acute Poisoning by Ergot.—In a fatal case of poisoning by ergot of rye, recorded by Dr. Davidson,† in which a hospital nurse, *æt.* 28, took ergot, the symptoms were mainly vomiting of blood, the passing of bloody urine, intense jaundice, and stupor. But in other cases, jaundice and vomiting of blood have not been recorded, and the general course of acute poisoning shows, on the one hand, symptoms of intense gastro-intestinal irritation, as vomiting, colicky pains, and diarrhœa; and, on the other, of a secondary affection of the nervous system, weakness of the limbs, aberrations of vision, delirium, retention of urine, coma, and death.

Physiological Action as shown by Experiments on Animals.—In spite of numerous experiments on animals and man, the action of the ergot principles remains obscure. It has been found in medicine to exert a specific action on the uterus,‡ causing powerful contractions of that organ, especially in labour. It is also a hæmostatic, and is used to check bleeding from the lungs and other internal organs of the body. This hæmostatic action, as well as the extraordinary property possessed by ergot, of producing an arrest or disturbance of the circulation inducing gangrene has naturally led to the belief that ergot causes a narrowing in the calibre of the small arteries, but this has not received the necessary experimental sanction. Holmes,* Eberty, Köhler,† and Wernick,‡ all observed a contraction in the part to which the ergot was applied, both in frogs and in warm-blooded animals; but L. Hermann,§ although he made many experiments, and used the most different preparations, never succeeded in observing a contraction. It would also seem reasonable to expect that with a narrowing of the vessels, which means a peripheral obstruction, the blood-pressure would rise, but, on the contrary, the pressure sinks, a fact on which there is no division of opinion.

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* In the *Phil. Trans.* for for 1762 there are two strictly concordant accounts of this case; and in the parish church of Wattisham, there is said to be a memorial tablet, which runs as follows:—"This inscription serves to authenticate the truth of a singular calamity which suddenly happened to a poor family in this parish, of which six persons lost their feet by a mortification not to be accounted for. A full narrative of their case is recorded in the Parish Register and *Philosophical Transactions* for 1762."

* *Lancet*, Sept. 30, 1882.

‡ In a case in which the author was engaged, a dabbler in drugs, having seduced a young woman, administered to her doses of ergot which produced a

Nikitin has made some researches with pure sclerotic acid, which certainly possesses the most prominent therapeutic effects of ergot; but since it is not the only *toxic* substance, it may not represent the collective action of the drug, just in the same way that morphine is not equivalent in action to opium. Cold-blooded animals are very sensitive to sclerotic acid; of the warm-blooded the carnivoræ are more sensitive than the herbivoræ. The toxic action is specially directed to the central nervous system—with frogs, the reflex excitability is diminished to full paralysis; with warm-blooded animals reflex excitability is only diminished, and continues to exist even to death.

The temperature falls, the breathing is slowed, and the respiration stops before the heart ceases to beat; the peristaltic action of the intestines is quickened, and the uterus (even of non-pregnant animals) is thrown into contraction. The terminations of the sensory nerves are paralysed by the direct action of the sclerotic acid, but they remain intact with general poisoning. The heart of frogs is slowed by sclerotic acid. Eberty observed that this slowing of the heart (he used ergotin) was produced even after destruction of the spinal cord; he therefore considered it as acting on the inhibitory nerve apparatus of the heart itself. Rossbach, using Wenzeln's

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miscarriage, and for that offence was convicted. The defence raised was that ergot is a common medicine used by physicians in the treatment of amenorrhœa, and other uterine affections. Although in itself this statement was perfectly true, as a defence it was invalidated by the large dose given, the fact of the seduction, and the other circumstances of the case.

[*] *Archiv d. Physiol. Norm. u. Pathol.*, iii., p. 384.

[†] *Ueber die Wirkungen des Secale Cornutum.* Dissert. Halle, 1873.

[‡] *Arch. f. Pathol. Anat.*, lvi., p. 505.

[§] *Lehrbuch der Exper. Toxicologie.* Berlin, 1874. p. 386.

ecbolin, has also studied its action on the heart of the frog, and observed that the slowing affected the ventricles rather than the auricles, so that for one ventricle-systole there were two contractions of the auricles; besides which, the contractions themselves were peculiar and abnormal in character. The cause of death from sclerotic acid seems to be paralysis of the respiration. It is said not to affect animal fœtal life. With regard to the effects produced by feeding animals with ergotised grain, experiments made during the last century have proved that it produces a gangrenous disease—*e. g.*, C. Salerné mixed one part of spurred rye with two of good barley, and fed pigs with the mixture; a few days afterwards the pigs perished with dilated, hard, and black bellies and offensively ulcerated legs; another pig fed entirely on the rye, lost its four feet and both ears.

Separation of the Active Principles of Ergot from Animal Tissues.—There has been no experience in the separation of the constituents of ergot from the organs of the body; an attempt might be made on the principles detailed in page 407, but success is doubtful.

II.—PICROTOXIN, THE ACTIVE PRINCIPLE OF THE *COCCULUS INDICUS* (INDIAN BERRY, LEVANT NUT).

The berries of the *Menispermum cocculus* comprise at least three definite crystalline principles: *menispermine*,[*] *paramenispermine* (nitrogen containing bases), and *picrotoxin*, which possesses some of the characters of an acid.

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[*] *Menispermine* ($C_{18}H_{24}N_2O_2$?), discovered in 1834 by Pelletier and Courbe, is associated with a second named *paramenispermine*. The powdered berries are extracted by alcohol of 36° ; the picrotoxin removed by hot water from the alcoholic extract; the menispermine and paramenispermine dissolved out together by acidulated water, and from this solution precipitated by ammonia. The brown precipitate is dissolved in acetic acid, filtered, and again precipitated by ammonia. This precipitate is dried, treated with cold alcohol, to separate a yellow resinous substance, and lastly with ether, which dissolves out the menispermine, but leaves the paramenispermine.

Menispermine forms white semi-transparent, four-sided, truncated prisms, melting at 120°, decomposed at a higher temperature, insoluble in water, but dissolving in warm alcohol and ether. Combined with 8 atoms of water it crystallises in needles and prisms. The crystals are without any taste; in combination with acids, salts may be formed.

Paramenispermine forms four-sided prisms, or radiating crystalline masses, melting at 250°, and subliming undecomposed. The crystals are soluble in absolute ether, insoluble in water, and scarcely soluble in ether.

Paramenispermine dissolves in acids, but apparently without forming definite salts.

Picrotoxin ($C_{12}H_{14}O_5$) was discovered in 1820 by Boullay. It is usually prepared by extracting the berries with boiling alcohol, distilling the alcohol off, boiling the alcoholic residue with a large quantity of water, purifying the watery extract with sugar of lead, concentrating the colourless filtrate by evaporation, and crystallising the picrotoxin out of water.

Picrotoxin crystallises out of water, and also out of alcohol, in colourless, flexible, four-sided prisms, often arborescent, and possessing a silky lustre. They are unalterable in the air, soluble in 150 parts of cold, and 25 parts of boiling, water, dissolving easily in acidified water, in spirit, in ether, in amyl alcohol, and chloroform. They are without smell, but have an extremely bitter taste. Caustic ammonia is also a solvent.

The crystals are neutral and bitter. They melt at a gentle heat to a yellow mass; at higher temperatures giving off an acid vapour, with a caramel-like odour, and lastly carbonising. Picrotoxin in cold concentrated sulphuric acid dissolves with the production of a beautiful gold-yellow to saffron-yellow colour, which becomes on the addition of a trace of potassic bichromate violet, passing into brown. An alcoholic solution turns a ray of polarised light to the left $[\alpha]j = -28{\cdot}1°$.

Picrotoxin behaves towards strong bases like a weak acid. Its compounds with the alkalies and alkaline earths are gummy and not easily obtained pure. Compounds with quinine, cinchonine, morphine, strychnine, and brucine can be obtained in the crystalline condition. Dilute sulphuric acid transformsit, with assimilation of water, into a weak gummy-like acid, which corresponds to the formula $C_{12}H_{16}O_6$. Nitric acid oxidises it to oxalic acid. Nitropicrotoxin and bromopicrotoxin ($C_{12}H_{13}(NO_2)O_5$, and $C_{12}H_{12}Br_2O_5$), can by appropriate treatment be obtained.

Concentrated aqueous solutions of alkalies and ammonia decompose picrotoxin fully on warming. It reduces alkaline copper solution, and colours bichromate of potash a beautiful green. The best test for its presence is, however, as follows:—The supposed pictrotoxin is carefully dried, and mixed with thrice its bulk of saltpetre, the mixture moistened with sulphuric acid, and then decomposed with soda-lye in excess, when there is produced a transitory brick-red colour. For the reaction to succeed, the picrotoxin should be tolerably pure.

Solutions of picrotoxin are not precipitated by the chlorides of platinum, mercury, and gold, iodides of potash, ferro and ferrid-cyanides of potash, nor by picric nor tannic acids.

Fatal Dose.—Vossler killed a cat in two hours with a dose of ·12 grm. (1·8 grain); and another cat, with the same dose, died in 45 minutes. Falck destroyed a young hound with ·06 grm. (·92 grain) in 24 to 26 minutes. Given by subcutaneous or intravenous injection, it is, as might be expected, still more lethal and rapid in its effects. In an experiment of Falck's, ·03 (·46 grain), injected into a vein, destroyed a strong hound within 20 minutes; ·016 grm. (·24 grain) injected under the skin, killed a guinea-pig in 22 minutes; and ·012 grm. (·18 grain) a hare in 40 minutes. Hence it may be inferred that from 2 to 3 grains (12·9 to 19·4 centigrms.) would, in all probability, be a dangerous dose for an adult person.

Effects on Animals.—The toxic action of picrotoxin on fish and frogs has been proposed as a test. The symptoms observed in fish are mainly as follows:—The fish, according to the dose, show uncertain motions of the body, lose their balance, and finally float to the surface, lying on one side, with frequent opening of the mouth and gill-covers. These symptoms are, however, in no way distinguishable from those induced by any poisonous substance in the water, or by many diseases to which fish are liable. Nevertheless, it may be conceded that in certain cases the test may be valuable—if, *e.g.*, beer be the matter of research, none of the methods used for the extraction of picrotoxin will be likely to extract any other substance having the poisonous action described on fish, so that, as a confirmatory test, this may be of use.

Frogs, under the influence of picrotoxin, become first uneasy and restless, and then somewhat somnolent; but after a short time tetanic convulsions set in, which might lead the inexperienced to imagine that the animal was poisoned by strychnine. There is, however, one marked distinction between the two—viz., that in picrotoxin poisoning an extraordinary swelling of the abdomen has been observed, a symptom which, so far as known, is due to picrotoxin alone. The frog is, therefore, in this instance, the most suitable object for physiological tests.

Beer extract containing picrotoxin is fatal to flies; but no definite conclusion can be drawn from this, since many bitter principles (notably quassia) are in a similar manner fatal to insect life.

Effects on Man.—Only two fatal cases of poisoning by picrotoxin are on record. In 1829 several men suffered from drinking rum which had been impregnated with *Cocculus inducus;* one died, the rest recovered. In the second case, a boy, aged twelve, swallowed some of the composition which was used for poisoning fish, the active principle of which was *Cocculus indicus;* in a few minutes the boy experienced a burning taste, he had pains in the gullet and stomach, with frequent vomiting, and diarrhœa. A violent attack of gastro-enteritis supervened, with fever and delirium; he died on the nineteenth day. The *post-mortem* signs were those usual in peritonitis: the stomach was discoloured, and its coats thinner and softer than was natural; there were also other changes, but it is obvious that, as the death took place so long after the event, any pathological signs found are scarcely a guide for future cases.

Physiological Action.—The convulsions are considered to arise from an excitation of the medulla oblongata; the vagus centre is stimulated, and causes spasm of the glottis and slowing of the heart's action during the attack. Rohrig also saw strong contraction of the uterus produced by *picrotoxin.* According to the researches of Crichton Browne, *chloral hydrate* acts in antagonism to picrotoxin, and prevents the convulsions in animals if the dose of picrotoxin is not too large.

Separation from Organic Matters.—Picrotoxin is extracted from aqueous acid solutions by either chloroform, amyl alcohol, or ether; the first is the most convenient. Benzene does not extract it, if employed in the same manner. On evaporation of the solvent the crude picrotoxin can be crystallised out of water, and its properties examined.

III.—THE POISON OF *ILLICIUM RELIGIOSUM*—A JAPANESE PLANT.

A new poison belonging to the picrotoxin class has been described by Dr. A. Langaard. In 1880, five children in Japan were poisoned by the seeds of the *Illicium religiosum;* three of the children died. Dr. Langaard then made various experiments on animals with an active extract prepared by exhaustion with spirit, and ultimate solution of the extract in water. Eykmann has also imperfectly examined the chemistry of the plant, and has succeeded in isolating a crystalline body which is not a glucoside; it is soluble in hot water, in chloroform, ether, alcohol, and acetic acid, but it is insoluble in petroleum ether; it melts at 175°, and above that temperature gives an oily sublimate. Langaard's conclusions are that all parts of the plant are poisonous. The poison produces excitation of the central apparatus of the medulla oblongata and clonic convulsions analogous to those produced by picrotoxin, toxiresin and cicutoxin. Before the occurrence of convulsions, the reflex excitability of frogs is diminished, the respiratory centre is stimulated, hence frequency of the respiration. Small doses cause slowing of the pulse through stimulation of the vagus and of the peripheral terminations of the vagus; in the heart the functional activity is later diminished. Small doses kill by paralysing the respiratory centre, large by heart paralysis. The proper treatment seems to be by chloral hydrate, for when animals are poisoned by small lethal doses it appears to save life, although when the dose is large it has no effect.—*Ueber die Giftwirkung von Japanischem Sternanis* (*Illicium religiosum*, Sieb.); *Virch. Archiv*, Bd. lxxxvi., 1881, S. 222.

IV.—CICUTOXIN.

The *Cicuta virosa*, a not very common umbelliferous plant growing in moist places, is extremely poisonous. It is from 3 to 4 feet in height, with white flowers; the umbels are large, the leaves are tripartite, the leaflets linear lanceolate, acute, serrate decurrent; the calyx has five leaf-like teeth, the petals are obcordate with an inflexed point; the carpels have five equal broad flattened ridges with solitary stipes. Böhm[*] succeeded, in 1876, in separating an active principle from this plant. The root was dried, powdered, and exhausted with ether; on evaporation of the ether the extract was taken up with alcohol, and after several days standing the filtrate was treated with petroleum ether; after removing the petroleum, the solution was evaporated to dryness in a vacuum; it was found to be a resinous mass, to which was given the name *cicutoxin*. It was fully soluble in alcohol, ether, or chloroform, and was very poisonous, but what its exact chemical nature may be is still unknown.

Effects on Animals.—Subcutaneously injected into frogs, cicutoxin acts something like picrotoxin, and something like the barium compounds. Ten to fifteen minutes after the injection the animal assumes a peculiar posture, holding the legs so that the thigh is stretched out far from the trunk, and the leg at right angles with the thigh; voluntary motion is only induced by the strongest stimuli, and when the frog springs he falls down plump with stiffly stretched-out limbs. The frequency of breathing is increased, the muscles of the abdomen are thrown into contraction, and the lungs being full of air, on mechanical irritation there is a peculiar loud cry, depending upon the air being forced under the conditions detailed through the narrow glottis. Tetanic convulsions follow, gradually paresis of the extremities appears, and, lastly, full paralysis and death; these symptoms are seen after doses of from 1 to 2 mgrms. The lethal dose for cats is about 1 centigrm. per kilo. Diarrhœa, salivation, and frequent breathing are first seen, and are followed by tonic and clonic convulsions, then there is an interval, during which there is heightened excitability of reflex action, so that noises will excite convulsions. Small doses by exciting the vagus slow the pulse; larger doses quicken the pulse, and raise the arterial pressure. Cicutoxin is supposed to act specially on the medulla oblongata, while the spinal cord and the brain are only secondarily affected.

Effects on Man.—F. A. Falck was able to collect thirty-one cases of poisoning by cicuta; of these 14 or 45·2 per cent. died. The symptoms are not dissimilar to those described in animals. There are pain and burning in the stomach, nausea, vomiting, headache, and then tetanic convulsions. These, in some cases, are very severe, and resemble those induced by strychnine; but in a few cases there is early coma without convulsions. There is also difficulty or absolute impossibility of swallowing. In fatal cases the respiration becomes stertorous, the pulse small, the pupils dilated, and the face cyanotic, and death occurs within some four hours, and in a few cases later. The *fatal dose* is unknown.

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[*] *Arch. f. Exp. Path.*, Bd. v., 1876.

Separation of Cicutoxin from the Body.—An attempt might be made to extract cicutoxin from the tissues on the same principles as those by which it has been separated from the plant, and identified by physiological experiments. In all recorded cases, identification has been neither by chemical nor physiological aids, but by the recognition of portions of the plant.

V.—ÆTHUSA CYNAPIUM (FOOL'S PARSLEY).

This plant has long been considered poisonous, and a number of cases are on record in which it is alleged that death or illness resulted from its use. Dr. John Harley,[*] however, in an elaborate paper, has satisfactorily proved the innocence of this plant, and has analysed the cases on record. He has experimented on himself, on animals, and on men, with the expressed juice and with the tincture. The results were entirely negative : some of the published cases he refers to conium, and others to aconite.

VI.—ŒNANTHE CROCATA.

The Water Hemlock.[†]—This, a poisonous unbelliferous plant, indigenous to England, and growing in moist places such as ditches, &c., is in flower in the month of August. It resembles somewhat celery, and the root is something like the parsnip, for which it has been eaten. All parts of the plant are said to be poisonous, but the leaves and stalks only slightly so, while the root is very deadly. We unfortunately know nothing whatever about the active principles of the plant; its chemistry has yet to be worked out. M. Toulmouche (*Gaz. Med.*, 1846) has recorded, as the expert employed in the case, an attempt to murder by using the

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[*] *St. Thomas' Hosp. Reports*, N. S., 1875.

[†] The earliest treatise on poisoning by the water-hemlock is by Wepfer, *Cicutæ Aquat. Historia et Noxæ*, 1679 ; for cases see Trojanowsky, *Dorp. Med. Ztg.*, 1875 ; Meyer, *Med. Zeitg. f. Preussen*, 1842 ; Schlesier in Casper's *Wochenschrift*, 1843 ; Maly, *Œster. Med. Wochenschr.*, 1844 ; Badgeley, *Montreal Med. Gaz.*, 1844 ; Lender, *Viertelj. f. Ger. Med.*, 1865; Gampf, *Cöln. Pharm. Zeitg.*, 1875 ; and the treatises of Taylor and others.

oenanthe as a poison; a woman scraped the root into her husband's soup with evil intent, but the taste was unpleasant, and led to the detection of the crime. The root has been mistaken several times for parsnip and other edible roots, and has thus led to poisonings. The case of 36 soldiers poisoned in this way, in 1758, has been recorded by Orfila; there was one death. In 1803 three soldiers were poisoned at Brest—1 died. In Woolwich, Bossey witnessed the poisoning of 21 convicts who ate the roots and leaves of the plant—6 died. In 1858 there were several sailors poisoned in a similar way—2 died; while there have been numerous cases in which the plant has been partaken of by children.

The effects of the poison may be gathered from a case of poisoning* which recently occurred at Plymouth; a Greek sailor, aged thirty, found on the coast what he considered "wild celery," and ate part of the root and some of the stem. Two hours after this he ate a good meal and felt perfectly well, but fifteen minutes later he suddenly and violently vomited; the whole contents of the stomach were completely evacuated. In five minutes he was completely unconscious, and had muscular twitchings about the limbs and face. There was a copious flow of a thick tenacious mucus from the mouth which hung about the lips and clothing in viscid strings. Twenty-four hours after the poisoning he was admitted into the South Devon Hospital apparently semi-comatose; his legs dragged, and he had only feeble control of them; the extremities were cold, but there was general free sweating. He could be roused only with difficulty. There were no spasms, the pupils were dilated and sluggish, the respiration only 14 per minute. Twelve hours after admission he became warmer, and perspired freely; he slept continuously, but could easily be roused. On the following day he was quite conscious, and made a good recovery. Two companions who had also eaten a smaller quantity of the hemlock dropwort, escaped with some numbing sensations, and imperfect control over the extremities. In the Woolwich cases the symptoms seem to have been something similar; in about twenty minutes, one man, without any apparent warning, fell down in strong convulsions, which soon ceased, although he looked wild; a little while afterwards his face became bloated and livid, his breathing stertorous and convulsive, and he died in five minutes after the first symptoms had set in. A second died with similar symptoms in a quarter of an hour, a third died in about an hour, a fourth in a little more than an hour; two other cases also proved fatal, one in nine days, the other in eleven. In the two last cases there were signs of intestinal irritation. The majority of the others fell down in a state of insensibility with convulsions, the after-symptoms being more or less irritation of the intestinal canal.

Post-mortem Appearances.—It was noticed in the Woolwich cases that those who died quickly had congestion of the cerebral vessels, and, in one instance, there was even extravasation of blood, but the man who died first of all had no congestion of the cerebral vessels. The lining membrane of the wind-pipe and air tubes was intensely injected with blood, and the lungs were gorged with fluid blood; the blood in the heart was black and fluid. The stomach and intestines were externally of a pink colour. The mucous membrane of the stomach was much corrugated, and the follicles particularly enlarged. In the two protracted cases the stomach was not reddened internally, but the vessels of the brain were congested.

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* *Lancet*, Dec. 18, 1882.

VII.—OIL OF SAVIN.

The leaves of the *Sabina communis*, or common savin, an evergreen shrub to be found in many gardens, contains a volatile oil, which has highly irritant properties. Savin leaves are occasionally used in medicine, maximum dose 1 grm. (15·4 grains). There is also a tincture —maximum dose, 3 cc. (about 45 mins.)—and an ointment made by mixing eight parts of savin tops with three of yellow wax and sixteen parts of lard, melting and digesting for twenty minutes, and then straining through calico.

The oil of savin is contained to the extent of about 2 per cent. in the leaves and 10 per cent. in the fruit. It has a peculiar odour, its specific gravity is ·89 to ·94, and it boils at 155° to 160°. An infusion of savin leaves (the leaves being drunk with the liquid) is a popular and very dangerous abortive

It is stated by Taylor that oil of savin has no abortive effect, save that which is to be attributed to its general effect upon the system, but this is erroneous. Röhrig found that, when administered to rabbits, it had a very evident effect upon the pregnant uterus, throwing it into a tetanic contraction. The action was evident after destruction of the spinal cord. The plant causes great irritation and inflammation, whether applied to the skin or taken internally. The symptoms are excruciating pain, vomiting, and diarrhœa, and the person dies in a kind of collapse.

In a case in which I was engaged some years ago, a woman, pregnant by a married man, took an unknown quantity of infusion of savin tops. She was violently sick, suffered great pain, with diarrhœa, and died in about twenty-six hours. The pharynx was much reddened, and the gullet even congested; the stomach was inflamed, and contained some greenish matter, in which I was able to detect savin tops, as well as to separate by distillation a few drops of strong savin-like smelling oil. The time which would elapse between the swallowing of the poison and the commencement of the pain was an important factor in this case, for the man was accused of having supplied her with the infusion. From the redness of the pharynx, and, generally, the rapid irritation caused by ethereal oils, I was of opinion that but a few minutes must have passed between the taking of the liquid and the sensation of considerable burning pain, although it is laid down in some works, as for example Falck's *Toxicologie,* that commonly the symptoms do not commence for several hours. Symptoms which have been noticed in many cases are—some considerable irritation of the urinary organs, such as strangury, bloody urine, &c.; in a few cases vomiting of blood, in others anæthesia, convulsions, and coma. Death may occur within twelve hours, or may be postponed for two or three days.

Post-mortem Appearances.—More or less inflammation of the bowels, stomach, and intestinal tract, with considerable congestion of the kidneys, are the signs usually found.

Separation of the Poison and Identification.—Hitherto reliance has been placed entirely on the finding of the savin tops, or on the odour of the oil. There is no reliable chemical test.

VIII.—CROTON OIL.

Croton oil is an oil expressed from the seeds of *Croton Tiglium,* a plant belonging to the natural order *Euphorbiaceæ,* growing in the West Indies. The seeds are oval in shape, not unlike castor-oil seeds, and about three-eighths of an inch in length. Both the seeds and the oil are very poisonous. The chemical composition of croton oil can scarcely be considered adequately settled. The most recent view, however, seems to be that it contains a fixed oil ($C_9H_{14}O_2$) with certain glycerides.[*] On saponifying and decomposing the soap a series of volatile fatty acids can be distilled over, the principal of which are methyl crotonic acid, with small quantities of formic, acetic, iso-butyric, valeric, and perhaps propionic, and other acids. The peculiar properties of croton are due rather to the fixed oil than to the volatile principles. The only officinal preparation in the British pharmacopœia is a "*croton oil liniment,*" containing one part of croton oil to seven of equal parts of oil of cajuput and rectified spirit.

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[*] G. Schmidt, *Arch. harm.* [3] 13, 213–229. Schlippe, Liebig's *Annalen,* 105, 1. Genther and Fröhlich, *Zeitschrift f. Chem.,* 1870, 26 and 549; *Journ. Chem. Society,* March 1879, p. 221.

Dose.—The oil is given medicinally as a powerful purgative in doses up to 65 mgrms. (about a grain). It is used externally as an irritant or vesicant to the skin. A very dangerous dose would be from fifteen to twenty times the medicinal dose.

Effects.—Numerous cases of poisoning from large doses of croton oil are recorded in medical literature, but the sufferers have mostly recovered. The symptoms are pain, and excessive purging and vomiting.

In the case of a chemist,† who took half an ounce of impure croton oil instead of cod-liver oil, the purging was very violent, and he had more than a hundred stools in a few hours ; there was a burning pain in the gullet and stomach, the skin was cyanosed, the pupils dilated, and great faintness and weakness were felt, yet the man recovered. A child, aged four, recovered from a teaspoonful of the oil given by mistake directly after a full meal of bread and milk. In five minutes there were vomiting and violent purging, but the child was well in two days. A death occurred in Paris, in 1839, in four hours after taking two and a half drachms of the oil. The symptoms of the sufferer, a man, were those just detailed, namely, burning pain in the stomach, vomiting, and purging. Singularly enough, no marked change was noticed in the mucous membrane of the stomach when examined after death. An aged woman died in three days from a teaspoonful of croton-oil embrocation ; in this case there were convulsions.

In the case of *Reg.* v. *Massey and Ferraud,** the prisoners were charged with causing the death of a man, by poisoning his food with jalap and six drops of croton oil. The victim, with others who had partaken of the food, suffered from vomiting and purging ; he became better, but was subsequently affected with inflammation and ulceration of the bowels, of which he died. In this case it was not clear whether the inflammation had anything to do with the jalap and croton oil or not, and the prisoners were acquitted. In a criminal case in the United States, a man, addicted to drink, was given, when intoxicated, two drachms of croton oil in a glass of whiskey. He vomited, but was not purged, and in about twelve hours was found dead. The mucous membrane of the stomach and small intestines proved to be much inflamed, and in some parts eroded, and croton oil was separated from the stomach.

Post-mortem Appearances.—Inflammation of the stomach and intestines are the signs usually found in man and animals.

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* *Révue de Thérapeut.*, May, 1881.

† *Orfila*, t. i., p. 108.

Chemical Analysis.—The oil may be separated from the contents of the stomach by ether. After evaporation of the ether, the blistering or irritant properties of the oil should be essayed by placing a droplet on the inside of the arm. There is no chemical test short of a complete analysis which could not be applied to the small quantities likely to be separated in a toxicological examination.

PART VI.—POISONS DERIVED FROM LIVING OR DEAD ANIMAL SUBSTANCES.

DIVISION I.—POISONS SECRETED BY LIVING ANIMALS.

I.—POISONOUS AMPHIBIA.

The glands of the skin of certain amphibia possess a secretion that is poisonous; the animal is unable to empty the poison glands by any voluntary act, but the secretion can readily be obtained by pressure. Zalesky found the juice in the skin glands of the *salamandra maculosa*, milky, alkaline in reaction, and bitter in taste. He isolated from it an organic base, which he named *Samandrine* ($C_{34}H_{60}N_2O_5$); it is soluble in water and in alcohol, and forms salts. Samandrine is a strong poison; injected subcutaneously into rabbits it causes shivering, epiletiform convulsions, and salivation; then tetanus, followed by oppressed respiration, dilated pupils, and anæsthesia. Death occurred after a kind of paralytic state. When given to dogs, it caused vomiting. In frogs, tetanus, occurred first and then paralysis—the result of all the experiments being that samandrine acted on the brain and spinal cord, leaving the heart and muscular substance unaffected. A similar secretion obtained from the water salamander (*Triton cristatus*), caused, according to Vulpian, the death of dogs in from three to eighteen hours; the symptoms being progressive weakness, slowing of the respiration, and depression of the heart's action.

The secretion of the skin of the common toad contains, according to Fornara, an alkaloid which is soluble in alcohol, and to which the name of *phrynine* has been applied; its action is toxic on all animals experimented upon, save toads. Administered to frogs, it causes rapid paralysis of the heart, and the breathing soon after ceases; the muscles become early rigid.

II.—THE POISON OF THE SCORPION.

There are several species of scorpions. The small European variety (*Scorpio europeus*) is found in Italy, the south of France, and the Tyrol; the African scorpion (*Bothus afer*, L.), which attains the length of 16 cm., is found in Africa and the East Indies; *Androctonus bicolor* in Egypt; and the *Androctonus occitanus* in Spain, Italy, Greece, and North Africa.

In the last joint of the tail the scorpion is provided with a poisonous apparatus, consisting of two oval glands, the canal of which leads into a round bladder, and this last is connected with a sting. When the sting is inserted, the bladder contracts, and expels the poison through the hollow sting into the wound. The smaller kinds of scorpion sting with as little general effect as a hornet, but the large scorpion of Africa is capable of producing death. There is first irritation about the wound, and an erysipelatous inflammation, which may lead to gangrene. Vomiting and diarrhœa then set in, with general weakness and a fever, which may last from one to one and a half days; in the more serious cases there are fainting, delirium, coma, convulsions, and death.

Valentin made some experiments on frogs with the *Androctonus occitanus*. He found that soon after the sting the animal remains quiet, but on irritation it moves, and is thrown into a transitory convulsion; to this follow twitchings of single muscular bundles. The frog is progressively paralysed, and the reflex irritability is gradually extinguished from behind forwards; at first the muscles may be excited by electrical stimuli to the nerves, but later they are only capable of contraction by direct stimuli.

III.—POISONOUS FISH.

Many species of fish possess in portions of the body a property which produces, when eaten, all the effects of poison. This is true, for example, of the perches, gurnards, flounders, spares, gobies, sardines, and globe-fishes, the last including two forms, *diodon* and *tetrodon*. The parts most dangerous are the spawn and liver. Not a few fishes can be eaten safely when young, but afterwards they become unwholesome, as, for instance, *Lethrinus mambo*. Sometimes it would seem that a poisonous property is imparted to an otherwise wholesome fish from its food; thus it has been noticed that the *Meletta venenosa* is only poisonous when it feeds on a certain green monad. The usual symptoms of poisoning by fish are nausea, vomiting, diarrhœa, great depression of the pulse, and painful cramps in the limbs. As examples of the intensely poisonous nature of certain fish may be cited cases of poisoning by the *diodon*, and some experiments on the goby.

In the *Linnean Transactions* for November, 1860, is recorded a fatal accident, which took place on board the Dutch ship "Postillion" at Simon's Bay, Cape of Good Hope. The boatswain and purser's steward partook of the liver of the *toad* or *ball-bladder* (diodon); within twenty minutes the steward died; in ten minutes the boatswain was violently ill; the face flushed, the eyes glistening, and the pupils contracted; there was cyanosis of the face, the pulse was weak and intermittent, and swallowing was difficult, the breathing became embarrassed, and the body generally paralysed. Death took place in seventeen minutes. The liver of one fish only is said to have been eaten. This might weigh four drachms. If the account given is literally correct, the intensity of the poison equals that of any known substance.

The poisonous nature of the goby has also led to several accidents, and we possess a few experiments made by Dr. Collas,* who fed chickens with different parts of the fish, and proved that all parts were alike poisonous. The effects were slow in developing; they commenced in about an hour or an hour and a half, and were well developed in five hours, mainly consisting of progressive muscular weakness and prostration. Death occurred without convulsions.

IV.—POISONOUS SPIDERS AND OTHER INSECTS.

It is probable that all spiders are poisonous; the only species, however, of which we have any definite information relative to their poisonous properties, are *Lycosa tarantula* and the *Latrodectus malmignatus*, to which may be added the New Zealand *katipo*. These spiders possess a poisonous gland connected with their masticatory apparatus, which secretes a clear, oily, bitter acid-reacting fluid; the acidity seems due to formic acid.

Zangrilli has observed several cases of tarantula bite; soon after the occurrence the part bitten is anæsthetic, after a few hours there are convulsive shiverings of the legs, cramps of the muscles, inability to stand, spasm of the pharyngeal muscles, quickening of the pulse, and a three days fever, with vomiting of yellow, bilious matter; recovery follows after copious perspiration. In one case there was tetanus, and death on the fourth day. The extraordinary effects attributed to the bite of the tarantula, called *tarantism* in the Middle Ages, are well detailed by Hecker:† this excitement was partly hysterical and partly delirious, and has not been observed in modern times.

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* *Soc. Sci. Rev.*, July 19, 1862; *Brit. and For. Med. Chir. Rev.*, Oct., 1862, p. 536

† "The Epidemics of the Middle Ages," by J. F. C. Hecker, translated by B. G. Babington, M.D., F.R.S. (*The Dancing Mania*, chap. ii., &c.)

Dax has described the effects of the bite of the *L. malmignatus*; it occasioned headache, muscular weakness, pain in the back, cramps, and dyspnœa; the symptoms disappeared after several days.

The *katipo* is a small poisonous spider confined to New Zealand. Mr. W. H. Wright has recorded the case of a person, who, in 1865, was bitten by this spider on the shoulder. The part rapidly became swollen, and looked like a large nettle-rash wheal; in an hour the patient could hardly walk, the respiration and circulation were both affected, and there was great muscular prostration; but he recovered in a few hours. In other cases, if the accounts given are to be relied upon, the bite of the spider has produced a chronic illness, accompanied by wasting of the body, followed by death after periods varying from six weeks to three months.[*]

Ants.—The various species of ants possess at the tail special glands which secrete *formic acid.* Certain exotic species of ants are provided with a sting, but the common ant of this country has no special piercing apparatus. The insect bites, and then squirts the irritating secretion into the wound, causing local symptoms of swelling and inflammation.

Wasps, &c.—Wasps, bees, and hornets all possess a poison-bag and sting. The fluid secreted is as clear as water, and of an acid reaction, it certainly contains formic acid, with some other poisonous constituent. An erysipelatous inflammation generally arises around the sting, and in those cases in which persons have been attacked by a swarm of bees, signs of general poisoning, such as vomiting, fainting, delirium, and stupor, have been noticed. Death has occasionally resulted.

Cantharides.—Commercial cantharides is either the dried entire, or the dried and powdered blister-beetle, or Spanish fly (*Cantharis vesicatoria.* The most common appearance is that of a greyish-brown powder, containing shining green particles, from which cantharidin is readily extracted by exhausting with chloroform, driving off the chloroform by distillation or evaporation, and subsequently treating the extract with disulphide of carbon, which dissolves the fatty matters only. Finally, the cantharidin may be recrystallised from chloroform, the yield being ·380 to ·570 per cent. Ferrer found in the wings and their cases, ·082 per cent.; in the head and antennæ, ·088; in the legs, ·091; in the thorax and abdomen, ·240; in the whole insect, ·278 per cent. Wolff found in the *Lytta aspera,* ·815 per cent.; Ferrer in *Mylabris cichorei,* ·1 per cent.; in *M. punctum,* ·193; and in *M. pustulata,* ·33 per cent. of *cantharidin.*

Cantharidin ($C_5H_{12}O_2$) has two crystalline forms—(1) Right-angled four-sided columns with four surfaces, each surface being beset with needles; and (2) flat tables. It behaves like the anhydride of an acid. It is soluble in alkaline liquids, and can be recovered from them by acidifying and shaking up with *ether, chloroform,* or *benzene;* it is almost completely insoluble in water. 100 parts of alcohol (99 per cent.) dissolve at 18° 0·125 part; 100 of bisulphide of carbon, at the same temperature, 0·06 part; ether, ·11 part; chloroform, 1·2 part; and benzene, ·2 part. Cantharidin can be completely sublimed, if placed in the subliming cell (described at p. 229), floating on mercury; a scanty sublimate of crystals may be obtained at so low a temperature as 82·5°; at 85° and above, the sublimation is rapid. If the cantharidin is suddenly heated it melts, but this is not the case if the temperature is raised gradually. Potassic chromate with sulphuric acid decomposes cantharidin with the production of the green oxide of chromium. An alkaline solution of potassic permanganate, iodic acid, and sodium amalgam, are all without influence on an alcoholic solution of cantharidin. With bases, cantharidin forms crystallisable salts, and, speaking generally, if the base is soluble in water, the "*cantharidate*" is also soluble; the lime and magnesic salts dissolve readily.

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[*] *Transac. of the New Zealand Inst.*, vol. ii., 1869. *Brit. and For. Med. Chir. Review*, July, 1871, p. 230.

Pharmaceutical Preparations of Cantharides.—The P. B. preparations of cantharides are—*Acetum cantharides,* or vinegar of cantharides, containing about ·04 per cent. of cantharidin.

Tincture of cantharides, containing about ·005 per cent. of cantharidin.

A solution of cantharides for blistering purposes, *Liquor epispasticus,* a strong solution of the active principle in ether and acetic acid, containing about ·16 per cent of cantharidin.

There are also—An *ointment;* a blistering paper, *Charta epispatica;* a blistering plaster, *Emplastrum cantharides;* and a warm plaster, *Emplastrum calefaciens.*

Fatal Dose.—It is difficult to state the fatal dose of cantharidin, the unassayed powder or tincture having mostly been taken. A young woman died from 1·62 grm. (25 grains) of the powder, which is perhaps equivalent to 6·4 mgrms. (·1 grain) of cantharidin, whilst the smallest dose of tincture known to have been fatal is (according to Taylor) an ounce. This would be generally equivalent to 15 mgrms. (·24 grain). Hence the fatal dose of cantharidin may be approximately stated as from 6 mgrms upward. But, on the other hand, recovery has taken place from very large doses.

Effects on Animals.—Certain animals do not appear susceptible to the action of cantharidin. For example, hedgehogs and swallows are said to be able to take it with impunity. Radecki * found that cantharidin might even be injected into the blood of fowls without any injury, and frogs also seem to enjoy the same impunity; while dogs, cats, and other animals are sensitive to the poison. Galippe ascertained that after the injection of 5 mgrms. into the veins of a dog, there was exaltation of the sexual desire; the pupils were quickly dilated; the dog sought a dark place, and became sleepy. Animals when poisoned die in asphyxia from paralysis of the respiratory centre. Schachowa * made some observations on the effect of cantharides on the renal excretion of a dog fed daily with 1 grm. in powder. On the third day, pus corpuscles were noticed; on the fifth, bacteria; on the thirteenth, the urine contained a large quantity of fatty matters, and several casts; and on the seventeenth, red shrivelled blood corpuscles were observed.

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* *Die Cantharidin Vergit.*, Diss., Dorpat, 1806.

Effects on Man.—Heinrich † made the following experiments upon himself:—Thirty living blister-beetles were killed, and digested, without drying, in 35 grms. of alcohol for fourteen days; of this tincture ten drops were taken. There ensued immediately a feeling of warmth in the mouth and stomach, salivation, the pulse was more frequent than in health, there was a pleasant feeling of warmth about the body, and some sexual excitement lasting three hours. In half an hour there was abdominal pain, diarrhœa, and tenesmus, and frequent painful micturition. These symptoms subsided in a few hours, but there was a want of appetite, and pain about the kidneys lasting until the following day. In a second experiment, on taking 1 cgrm. of cantharidin, there were very serious symptoms of poisoning. Blisters formed on the tongue, and there was salivation, with great difficulty in swallowing, and a general feeling of illness. Seven hours after taking the poison, there were frequent micturitions of bloody urine, diarrhœa, and vomiting. Twenty hours after the ingestion the face was red, the skin hot, the pulse twenty beats beyond the normal pulsation, the tongue denuded to two-thirds of its extent of its epithelium, and the lips and mucous membrane red and swollen; there was great pain in the stomach, intestines, and in the neighbourhood of the kidneys, continuous desire to micturate, burning of the urethra, and swelling of the glands. There was no sexual excitement whatever; and the urine was ammoniacal, and contained blood and pus, the symptoms gradually subsided, but recovery was not complete for fourteen days.

The foregoing is a fair picture of what may be expected in cantharides poisoning. It is remarkable that the popular idea as to the influence of cantharidin in exciting the sexual passion, holds good only as to the entire cantharides, and not with cantharidin. It is very possible that cantharidin is not the only poisonous principle in the insect. The symptoms in other cases, fatal or not, have been as follows:—Immediate burning in the mouth and throat, extending to the stomach and alimentary canal, and increasing in intensity until there is considerable pain. Then follow salivation, difficulty in swallowing, and vomiting, and generally diarrhœa, pain in the kidneys, irritation of the bladder, priapism, and strangury are all present. The pulse is accelerated, the breathing disturbed, there are pains in the head, and often mydriasis, giddiness, insensibility, delirium, and convulsions; trismus has been noticed. The desire to micturate frequently is urgent, the urine is generally bloody, and contains pus. Pregnant women have been known to abort. In a few of the cases in which a different course has been run, the nervous symptoms have predominated over those of gastro-intestinal irritation, and the patient has sunk in a kind of collapse. In a case of chronic poisoning by cantharides, extending over three months, and recorded by Tarchioni Bonfanti,* after the first dose appeared tetanic convulsions, which subsided in twenty-four hours, there was later cystitis, and from time to time the tetanic convulsions returned; gastro-enteritis followed with frequent vomiting, when cantharides being found in the matters ejected, the otherwise obscure nature of the illness was shown.

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* *Unters. über die Nieren*, Diss. Bern, 1877; Cornil, *Gaz. Méd.*, 1880.

† Schroff, *Zeitschrift d. Ges. d. Aerzte. in Wien*, 13, 56.

In a case recorded by Sedgwick,† following the gastro-enteric symptoms, there were epileptic convulsions; in this instance also was noticed an unpleasant smell, recalling the notion formerly held that cantharides imparted a peculiar odour to the breath and urine. In a case of chronic poisoning related by Tardieu, six students during several months used what they thought was pepper with their food, but the substance proved to be really powdered cantharides. The quantity taken each day was probably small, but they suffered from pain about the loins, and also irritation of the bladder. There was no sexual excitement.

Post-mortem Appearances.—In a French criminal case, in which a man poisoned his step-brother by giving cantharides in soup, the pathological signs of inflammation of the gastro-intestinal tract were specially evident, the mouth was swollen, the tonsils ulcerated, the gullet, stomach, and intestines were inflamed, and the mucous membrane of the intestines covered with purulent matter. In another case there was an actual perforation three inches from the pylorus. The inflammatory appearances, however, are not always so severe, being confined to swelling and inflammation without ulceration. In all cases there has been noted inflammation of the kidneys and urinary passages, and this is seen even when cantharidin is administered to animals by subcutaneous injection.

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* *Gaz. Med. Ital.*, Lomb., 1863.

† *Med. Times*, 1864.

In the urine will be found blood and fatty epithelial casts, as well as pus. The contents of the stomach or the intestines will probably contain some remnants of powdered cantharides, if the powder itself has been taken.

Tests for Cantharidin and its Detection in the Tissues, &c.—The tests for cantharidin are—(1) Its form, (2) its action in the subliming celi, and (3) its power of raising a blister.

The most convenient method of testing its vesicating properties, is to allow a chloroformic solution of the substance supposed to be cantharidin to evaporate to dryness, to add to this a drop of olive oil (or almond oil), and to take a drop up on the smallest possible quantity of cotton wool, and apply the wool to the inside of the arm, covering it with good oilskin, and strapping the whole on by the aid of sticking-plaster. In about an hour or more the effect is examined. The thin skin of the lips is far more easily blistered than that of the arm, but the application there is inconvenient.

Dragendorff has ascertained that cantharidin is not present in the contents of a blister raised by a cantharides plaster, although it has been found in the urine of a person treated by one; and Pettenkoffer has also discovered cantharidin in the blood of a boy to whose spine a blister had been applied.

The great insolubility of cantharidin in water has led to various hypotheses as to its absorption into the system. Dragendorff considers it as the anhydride of an acid, which is tolerably easily dissolved by potash, soda, and ammonia solutions, and is also taken up in small proportion by sulphuric, phosphoric, and lactic acids. The resulting compounds quickly diffuse themselves through animal membranes. Even the salts with lime, magnesia, alumina, and the heavy metals, are not quite insoluble. A solution of salt with cantharidin, put in a dialysing apparatus, separates in twenty-four hours enough cantharidin to raise a blister.

Cantharidin has actually been discovered in the heart, brain, muscles, contents of the stomach, intestines, and fæces (as well as in the blood and urine) of animals poisoned by the substance. A urine containing cantharidin is alkaline and albuminous. Cantharidin, although readily decomposed by chemical agents, is so permanent in the body that it has been detected in the corpse of a cat eighty-four days after death.

In any forensic case, the defence will not improbably be set up that some animal (*e.g.*, a fowl poisoned by cantharides) has been eaten and caused the toxic symptoms, for cantharides is an interesting example of a substance which, as before stated, for certain animals (such as rabbits, dogs, cats, and ducks), is a strong poison, whilst in others (*e.g.*, hedgehogs, fowls, turkeys, and frogs), although absorbed and excreted, it appears inert. Experiment has shown that a cat may be readily poisoned by a fowl saturated with cantharides; and in Algeria the military surgeons meet with cystitis among the soldiers, caused by eating frogs in the months of May and June, the frogs living in these months almost exclusively on a species of cantharides.

Dragendorff recommends the following process:—The finely-pulped substance is boiled in a porcelain dish with potash-lye (1 part of potash and 12 to 18 of water) until the fluid is of a uniform consistence. The fluid, after cooling, is (if necessary) diluted with an equal bulk of water, for it must not be too thick; then shaken with chloroform in order to remove impurities; and after separation of the chloroform, strongly acidified with sulphuric acid, and mixed with about four times its volume of alcohol of 90 to 95 per cent. The mixture is kept for some time at a boiling temperature, filtered hot, and the alcohol distilled from the filtrate. The watery fluid is now again treated with chloroform, as above described. The chloroform extract is washed with water, the residue taken up on some hot almond oil, and its blistering properties investigated. The mass, heated with potash in the above way, can also be submitted to dialysis, the diffusate supersaturated with sulphuric acid, and shaken up with chloroform.

In order to test further for cantharidin, it can be dissolved in the least possible potash or soda-lye. The solution, on evaporation in the water-bath, leaves crystals of a salt not easily soluble in alcohol, and the watery solution of which gives with chloride of calcium and baryta a white precipitate; with sulphate or copper and sulphate of protoxide of nickel, a green; with cobaltous sulphate, a red; with sugar of lead, mercury chloride and argentic nitrate, a white crystalline precipitate. With palladium chloride there occurs a yellow, hair-like, crystalline precipitate; later crystals, which are isomorphous with the nickel and copper salts.

If the tincture of cantharides has been used in considerable quantity, the urine may be examined; in such a case there will collect on the surface drops of a green oil, which may be extracted by petroleum ether; this oil is not blister-raising. Cantharides in powder may, of course, be detected by its appearance.

To the question whether the method proposed would extract any other blister-producing substance, the answer is negative, since ethereal oil of mustard would be decomposed, and the active constituents of the *Euphorbias* do not withstand the treatment with KHO. Oils of anemone and anemonin are dissolved by KHO, and again separated out of their solutions, but their blistering property is destroyed. They are volatile, and found in anemone and some of the *Ranunculaceæ*. In the *Aqua pulsatilla* there is an oil of anemone, which may be obtained by shaking with ether; but this oil is not permanent, and if the *Aqua pulsatilla* stand for a little time, it splits up into anemonic acid and anemonin, and then cannot be reöbtained. A blistering substance, obtained from the *Anacardia orientalia* and the fruit of the *Anacardium occidentale* and *Semecarpus anacardium*, is not quite destroyed by a short action with potash, but is by one of long duration; this substance, however, cannot be confused with cantharidine, for it is oily, yellow, easily soluble in alcohol and ether, and differs in other respects.

V.—SNAKE POISON.

The poisonous snakes belong chiefly to two classes, the ***Proteroglypha*** and the *Solenoglypha*. The practical difficulty in the investigation of snake-venom is such that, notwithstanding the interest of the subject, but little definite is known of the chemistry of the poison of any snake save that of the cobra.

The Poison of the Cobra.—The poison excreted from the salivary glands of the cobra di capello is the most deadly animal fluid known. When first ejected, it is an amber-coloured, rather syrupy, frothy liquid, of specific gravity 1·046, and of feeble acid reaction; it dries rapidly on exposure to air to a yellow film, which readily breaks up into brilliant yellow granules, closely imitating crystals. The yellow powder is very acrid and pungent to the nostrils, and excites a painful (though transitory) inflammation, if applied to the mucous membrane of the eye; the taste is bitter, and it raises little blisters on the tongue. It is perfectly stable, and preserves its activity for an indefinite time. The dried poison as described is perfectly soluble in water, and if the water is added in proper proportions, the original fluid is without doubt reproduced, the solution usually depositing a sediment of epithelial *débris*, and often containing little white shreds.

The poison has been examined by several chemists, but until of late years with a negative result. The writer was the first to isolate, in 1876, a crystalline principle, which appears to be the sole active ingredient; the yellow granules were dissolved in water, the albumen which the venom so copiously contains coagulated by alcohol, and separated by filtration; the alcohol was then driven off at a gentle heat, the liquid concentrated to a small bulk, and precipitated with basic acetate of lead. The precipitate was separated, washed, and decomposed in the usual way by SH_2, and on removing the lead sulphide, crystals having toxic properties were obtained.

Pedler,* precipitating the albumen by alcohol, and then to the alcoholic solution adding platinic chloride, obtained a semi-crystalline precipitate, which from an imperfect combustion he thinks may have something like the composition $PtCl_4(C_{17}H_{25}N_4O_7HCl)_2$. I have examined the platinum compound, and made several combustions of different fractions, but was unable to obtain the compound in a sufficient state of purity to deduce a formula. My analysis agreed with those of Pedler for nitrogen—viz., 9·93 per cent. (Pedler, 9·69); hydrogen 4·17 (Pedler, 4·28); but were higher for carbon, 41·8 per cent. (Pedler, 33·42 per cent.); one fraction 7·3 per cent. of platinum, another double that amount. Material was insufficient to thoroughly investigate the compound, but it was evident that several double salts were formed.

Fatal Dose.—From my experiments on cats, rabbits, and birds, it seems probable that the least fatal dose for cats and rabbits lies between ·7 and ·9 mgrm. per kilo., and for birds somewhere about ·7 mgrm. per kilo. of the dried poison; the venom contains about 60 per cent. of albuminous matter, and about 10 per cent. of poisonous substance; therefore, the lethal power is represented by something like ·07 to ·09 mgrm. per kilo., if the pure toxic principle free from albumin and diluting impurities be considered.

Effects on Animals.—Almost immediately local pain or signs of uneasiness at the seat of injection are observed. There is then a variable interval, seldom exceeding 20 minutes (and generally much less), but in one of my experiments half an hour elapsed after the injection of a fatal dose before any effect was evident. The symptoms once produced, the course is rapid, and consists, first, of acceleration of the respirations, and then a progressive slowing, soon followed by convulsions. The convulsions are probably produced by the interference with the respiration and the deficient oxidation of the blood, and are, therefore, the so-called "carbonic acid convulsions." There is paresis or paralysis of the limbs. Death seems to occur from asphyxia, and the heart beats for one or more minutes after the respirations have ceased. If the dose is so small as not to produce death, no after-effects have been observed; recovery is complete.

Sir J. Fayrer and Dr. Lauder Brunton consider that the terminations of the moter nerves suffer; on the other hand, Dr. Wall would explain the phenomena by referring the action entirely to the central nervous system, and concludes that the effects of the cobra poison consist in the extinction of function extending from below upwards of the various nerve centres constituting the cerebro-spinal system. In addition to this, there is a special and rapid action on the respiratory and allied nuclei, and this it is that causes death.

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* *Proc. Roy. Soc.*, vol. xxvii., p. 17.

Effects on Man.—By far the best account hitherto published of the effects of the cobra poison is the paper by Dr. Wall,[*] in which he points out the very close similarity between the symptoms produced and those of glosso-pharyngeal paralysis. This is well shown in the following typical case:—A coolie was bitten on the shoulder about twelve at midnight by a cobra; he immediately felt burning pain at the spot bitten, which increased. In fifteen minutes afterwards he began, he said, to feel intoxicated, but he seemed rational, and answered questions intelligently. The pupils were natural, and the pulse normal; the respirations were also not accelerated. He next began to lose power over his legs, and staggered. In thirty minutes after the bite his lower jaw began to fall, and frothy viscid mucous saliva ran from his mouth; he spoke indistinctly, like a man under the influence of liquor, and the paralysis of the legs increased. Forty minutes after the bite, he began to moan and shake his head from side to side, and the pulse and respirations were somewhat accelerated; but he was still able to answer questions, and seemed conscious. There was no paralysis of the arms. The breathing became slower and slower, and at length ceased one hour and ten minutes after the bite, the heart beating for about one minute after the respiration had stopped.

There is often very little sign of external injury, merely a scratch or puncture being apparent, but the areolar tissue lying beneath is of a purple colour and infiltrated with a large quantity of coagulable, purple, blood-like fluid. In addition, the whole of the neighbouring vessels are intensely injected, the injection gradually diminishing as the site of the poisoned part is receded from, so that a bright scarlet ring surrounds a purple area, and this in its turn fades into the normal colour of the neighbouring tissues. At the margin is also a purple blood-like fluid, replaced by a pinkish serum, which may often be traced up in the tissues surrounding the vessels that convey the poison to the system, and may extend a considerable distance. These appearances are to be accounted for in great part by the irritant properties of the cobra venom. The local hyperæmia and the local pain are the first symptoms. In man there follows an interval (which may be so short as a few minutes, or so long as four hours) before any fresh symptoms appear; the average duration of the interval is, according to Dr. Wall, about an hour. When once the symptoms are developed, then the course is rapid, and as in the case quoted, a feeling like that of intoxication is first produced, and then loss of power over the legs. This is followed by a loss of power over the speech, over swallowing, and the movement of the lips; the tongue becomes motionless, and hangs out of the mouth; the saliva is secreted in large quantities, and runs down the face, the patient being equally unable to swallow it or to eject it, and the glosso-pharyngeal paralysis is complete.

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[*] "On the difference of the physiological effects produced by the poison of Indian venomous snakes," by A. T. Wall, M.D., *Proc. Roy. Soc.*, 1881, vol. xxxii., p. 333.

Antidotes and Treatment.—Professor Halford some years ago proposed ammonia, and M. Lacerda in recent times has declared potassic permanganate an antidote to the cobra poison. The ammonia theory has been long disproved, and before Lacerda had made his experiments I had published the chemical aspect of some researches,* when I stated that mixing the cobra venom with an alkaline solution of potassic permanganate destroyed its poisonous properties, and I had also made experiments in every conceivable way with potassic permanganate, injecting it simultaneously in different parts of the same animal's body, and had proved that it had no antidotal power whatever over the living subject. Dr. Shortt had also, long before my own experiments, proved the same thing, and since the publication of Lacerda's extraordinary communication, other observers have given the matter a fair trial, and refuted completely the antidotal properties of potassic permanganate.† It acts only when it comes directly into contact with the venom, but when the venom is once absorbed into the circulation potassic permanganate, whether acid, alkaline, or neutral, is powerless. That it is of great use when applied to a bite is unquestionable, for it neutralises or changes any of the venom hanging about the wound, and which, if allowed to remain, might yet be absorbed; but here it is obvious that the venom is, so to speak, outside the body. The general treatment most likely to be successful is the immediate sucking of the wound, followed by the application of an alkaline solution of permanganate; and lastly, if the symptoms should neverthless develop, and an attempt should be made to maintain the breathing by galvanism and artificial respiration.‡

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* *Analyst*, Feb. 28, 1877.

† See Note on the effect of various substances in destroying the activity of the cobra poison. By T. Lauder Brunton and Sir J. Fayrer, *Proc. Roy. Soc.*, vol. xxvii., p. 17.

‡ Some of my experiments on the cobra poison may be briefly detailed, illustrating the general statement in the text:—

1. A quantity equal to 1 mgrm. of the dried venom was injected subcutaneously into a chicken. The symptoms began in two minutes with loss of power over both legs. In eight minutes the legs were perfectly paralysed. There were convulsive movements of the head and wings, slowing of the respiration, and death in ten minutes. The same quantity of poison was treated with a little tannin, and the clear liquid which separated from the precipitate injected into another chicken. The respiration became affected in ten minutes; in eighteen minutes the bird had become very quiet, and lay insensible; in twenty minutes it was dead, the respiration ceasing before the heart.

Detection of the Cobra Venom.—In an experiment on a rabbit, the animal was killed by the subcutaneous injection of 8 mgrms. per kilo. of the cobra poison. Immediately after death, 2 cc. of the blood were injected into a small rabbit; in fifteen minutes there was slow respiration with pains in the limbs; in thirty minutes this had, in a great measure,

2. In seven experiments with cobra poison, first rendered feebly alkaline with an alkaline solution of potassic permanganate, no effect followed. Three of the experiments were on chickens, four on rabbits.

3. A chicken was injected with 1 mgrm. of cobra poison in one leg, and in the other simultaneously with a solution of potassic permanganate. Death followed in sixteen minutes. Another chicken was treated in the same way, but with injections of potassic permanganate solution every few minutes. Death resulted in thirty-seven minutes. Four other similar experiments were made—two with feebly alkaline permanganate, two with permanganate made feebly acid with sulphuric acid—but death occurred with the usual symptoms.

4. Cobra poison was mixed with a weak solution of iodine, and a quantity equal to half a mgrm. was injected into a chicken. The symptoms began directly, were fully developed in ten minutes, and death took place in twenty-one minutes.

5. Equal volumes of cobra venom and aldehyde were mixed, and a quantity equivalent to 1 mgrm. of the cobra poison injected. The symptoms were immediate paralysis and insensiblity, and the respiration rapidly fell. Death occurred in four minutes without convulsions.

6. The cobra venom was mixed with a feebly alkaline solution of pyrogallic acid, and injected subcutaneously into a chicken. In six minutes the usual symptoms commenced, followed in thirteen minutes by death.

7. One mgrm. was injected into a chicken. The respirations at the commencement were 120; in twenty-two minutes they sank to 96, in twenty-five minutes to 84, in twenty-seven minutes to 18, and then to occasional gasps, with slight movement of the wings and toes. There was death in thirty-two minutes after the injection.

8. A young rabbit was injected with ·5 mg. (equal to 1 mgrm. per kilo.) of cobra poison. In two hours it was apparently moribund, with occasional short gasps. Artificial respiration was now attempted. There was considerable improvement, but it was intermitted during the night, and the animal was found dead in the morning, having certainly lived six hours.

9. A strong healthy kitten was injected with 1 mgrm. of cobra venom (equal to 5 mgrms. per kilo.) In twenty minutes the symptoms were well developed, and in an hour the animal was gasping—about twelve short respirations per minute. Artificial respiration was kept up for two hours, and the animal recovered, but there was great muscular weakness lasting for more than twenty-four hours.

10. A brown rabbit, weighing about 2 kilos., was injected with 12 mgrms. (6 per kilo.) of the cobra poison. The symptoms developed within ten minutes; ammonia was injected, and also given by the nostril. The heart's action which, previous to the adminstration of the ammonia, had been beating feebly, became accelerated, but death followed within the hour, the heart beating two minutes after the respiration had ceased.

11. A brown rabbit, about 2 kilos. in weight, was injected with 1·5 mgrms.

passed off, and in a little time the animal was well. In any case in which it is necessary to attempt to separate the cobra venom, the most likely method of succeeding would be to make a cold alcoholic extract, evaporate in a vacuum, take up the residue in a little water, and test its effect on small animals.

Duboia Russellii.—The Duboia russellii, or *Russell's viper,* is one of the best known and most deadly of the Indian vipers. The effects of the poison of this viper are altogether different from those of the cobra. The action commences by violent general convulsions, which are often at once fatal, or may be followed by rapid paralysis and death; or these symptoms, again, may be recovered from, and death follow at a later period. The convulsions do not depend on asphyxia, and with a small dose may be absent. The paralysis is general, and may precede for some time the extinction of the respiration, the pupils are widely dilated, there are bloody discharges, and the urine is albuminous. Should the victim survive the first effects, then blood poisoning may follow, and a dangerous illness result, often attended with copious hæmorrhages. A striking example of this course is recorded in the *Indian Med. Gaz.,* June 1, 1872.

A Mahommedan, aged 40, was bitten on the finger by Russell's viper; the bitten part was soon after excised, and stimulants given. The hand and arm became much swollen, and on the same day he passed blood by the rectum, and also bloody urine. The next day he was sick, and still passing blood from all the channels; in this state he remained eight days, losing blood constantly, and died on the ninth day. Nothing definite is known of the chemical composition of the poison; it is probably qualitatively identical with "viperin."

The Poison of the Common Viper.—The common viper still abounds in certain parts of Great Britain, as, for example, on Dartmoor. The venom was analysed in a partial manner by Valentin. In 1843 Prince Lucien Bonaparte separated a gummy varnish, inodorous, glittering, and transparent, which he called *echidnin* or *viperin;* it was a neutral, nitrogenous body without taste, it arrested the coagulation of the blood, and,

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of cobra poison (·75 per kilo.) There were no symptoms for nearly an hour, then sudden convulsions, and death.

12. Another rabbit of the same size was treated similarly, but immediately after the injection made to breathe nitrous oxide; death took place in thirty minutes. A rabbit, a little over 2 kilos. in weight, was injected with 7 mgrms. of cobra venom per kilo., and then 10 mgrms. of monobremated camphor were administered. In fifteen minutes there was general paralysis of the limbs, from which in a few minutes the animal seemed to recover; thirty minutes after the injection there were no very evident symptoms, but within forty minutes there was a sudden accession of convulsions, and death. Experiments were also made with chloroform, morphine, and many other substances, but none seemed to exercise any true antidotal effect.

injected into animals, produced all the effects of the bite of the viper. The effects of the viper poison are strikingly like those of the more venomous duboia, and as Dr. Giuseppe Badaloni* has shown that the ordinary viper, in cold weather, is scarcely poisonous, it is highly probable that future investigation will establish the complete qualitative identity of the poison secreted by the various members of the viperine class. The symptoms are dilatation of the pupil, progressive diminution of temperature, convulsions, diminution of blood-pressure, and paralysis, followed by death. The course is usually very rapid. After death the blood is found fluid, and there are numerous hæmorrhagic points in the mucous membranes and organs of the body.

The Rattlesnake.—The rattlesnake (*crotalus*) secretes a poison which, in 1861, was investigated by Mr. Weir Mitchell. He considered the active principles to consist of an albuminoid body. The effects of the rattlesnake bite are, so far as known, strikingly like those produced by vipers, and it is possible that the poison is also chemically identical with "viperin."

DIVISION II.—POISONS FORMED IN DEAD ANIMAL MATTERS.

I.—PTOMAINES—CADAVERIC ALKALOIDS.

It has long been known that, in putrefying animal substances, more or less definite poisonous principles arise. Letheby, many years ago, separated several of these; and Dr. W. B. Richardson succeeded in crystallising the hydrochlorate of a base, from a pyæmic fluid, and showed it to possess remarkable toxic effects. Marquardt, of Stettin, also discovered a cadaveric alkaloid, which he named *septicin*. Other researches followed, and the names of Panum,† Bergmann, ‡ Schmiedeberg, Schmidt,§ Zuelzer, Sonnenschein,‖ and W. Schwanert will be remem-

* *Lancet*, May 5, 1883.

† Virchow's *Archiv f. Path. Anat.*, Bd. xxvii., S. 240. See also Bd. xxviii., xxvx. and lx.

‡ *Das putride Gift u. die putride Infection.* Dorpat, 1869.

§ Schmidt, *Untersuch. über das Sepsin.* Inaug. Dissert., Dorpat, 1869.

‖ *Berlin. Klin. Wochenschr.*, 1869, Nro. 12.

bered as having contributed to our present knowledge of the matter. It is, however, Francesco Selmi* who made the first prolonged and methodical study of the whole question, and has shown its great chemico-legal importance.

The general method used by Selmi in extracting the ptomaines was to make an alcoholic extract very much after the method of Stas; and then after filtration to evaporate the alcoholic extract in a vacuum. This he effected by placing the alcoholic solution in a Wolfe's bottle; the one tubule being connected with a long tube dipping into mercury, which served the purposes of a manometer, the other united to a globular, well-cooled receiver, which in its turn was connected with a vacuum pump. The liquids were thus evaporated down to extracts at from 30° to 35°, an aqueous solution was then made of the extract, and the soluiton shaken up with solvents, the solution itself either remaining acid, or being alkalised by baryta. He attempted to purify the ptomaines obtained in this way by several methods. Sometimes the ptomaine was so alkaline that a current of CO_2 would be sufficient to precipitate it. More often it was precipitated from its acid solution by means of baryta, and the pasty mass was exhausted with ether; occasionally an ethereal solution of tartaric acid was used, and the tartrate decomposed with iodine in hydriodic acid ($HI+I$). His chief results were as follows:—

Ptomaines extracted from the Acid Liquid by means of Ether.— The substances extracted by ether gave precipitates with tannin, iodine in hydriodic acid, and gold chloride. Some gave a precipitate with corrosive sublimate, others not. Some gave a rose-red colour with sulphuric acid; with nitric acid, they all yellowed more or less. In one case a substance, which gave a remarkably fragrant odour when heated with sulphuric acid and then neutralised by sodic carbonate, was separated, resembling the odour of atropine when treated similarly. A physiological experiment with this fragrant body, showed that it was poisonous, but it killed in a different manner from atropine, and produced only a temporary dilatation of the pupil.

Another substance extracted from an acid solution, struck a violet-hue in the cold with sulphuric acid. Iodic acid and gold chloride were immediately reduced. The sulphuric acid, left to itself for a few days, turned yellow, and emitted an aromatic odour.

Ptomaines extracted from an Alkaline Liquid by means of Ether.— Selmi notices that, generally speaking, the ptomaines extracted in this way soon decompose and develop a cadaveric odour. They dilate the pupil, but only temporarily; they taste pungent or bitter, benumb the tongue, and cause a feeling of suffocation in the throat; they sometimes increase the cardiac action, sometimes diminish it. In eighteen experiments six, or one-third, produced the death of frogs, with the heart in systole and empty. Their chemical characteristics are those of alkaloids; they are alkaline in reaction, and are precipitated by general alkaloidal reagents. The following are some of the substances mentioned by Selmi:

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* Selmi. *Sulle Ptomaine od Alcaloide Cadaverici, e lore importanza in Tossicologia.* Bologna, 1877. See also *Atti dei Lincei*, vol. ii., 1878 and 1879. "The Ptomaines and their Significance in Judicial and Toxicological Chemistry," by Professor Husemann, *Chem. News*, June 2, 1882. For other papers on Ptomaines, see the Bibliography at end of this article.

A substance becoming violet with strong sulphuric acid.

A substance reducing iodic acid.

A substance which gave a yellow-red precipitate with acetate of copper, and was also precipitated by corrosive sublimate and phosphomolybdic acid.

A substance giving a violet tint passing into red with cold sulphuric acid, the red not being discharged by the addition of bromine water. Fröhde's reagent, as well as sulphuric acid, mixed with cerium oxide, also struck a red colour with the same substance.

A substance giving a red with sulphuric acid like the last, but differing from it, for bromine water discharged the colour.

A substance which gave a violet colour on treating a dried drop of the solution with three drops of hydrochloric acid, and then gently heating.

An alkaline substance giving a violet colour with phosphoric acid.

He also found at least two ptomaines, which gave crystalline precipitates with iodine in hydriodic acid—the one separated in yellow scales, the other in needles arranged in digitate groups.

Ptomaines extracted by Chloroform.—After shaking up with ether the liquid was then acted on by chloroform. Those dissolved by this solvent had mostly a strong alkaline reaction; the taste was pungent and sometimes bitter, benumbing the tongue. They easily decomposed, and generally reduced iodic acid. In one case there was a red colour with sulphuric acid, and the substance behaved not unlike delphinin. A few formed crystalline compounds with HI+I.

Ptomaines extracted by Amylic Alcohol.—Selmi found some of the ptomaines insoluble in ether or chloroform, but soluble in amylic alcohol. A ptomaine obtained by this solvent gave, with iodine in hydriodic acid, a red-brown precipitate, which, when examined without loss of time by the microscope, showed crystals, but the crystals gradually decomposed into yellow drops. A physiological experiment showed that it was not poisonous. Another alkaloid extracted in the same way gave with HI+I brown crystals in long laminæ. Injected subcutaneously, it killed a rabbit in two minutes in tetanic convulsions. Another ptomaine, from a corpse exhumed a year after death, was non-crystaliine, but very poisonous; injected into a rabbit it produced dilatation of the pupil, tetanic convulsions, and death in two and a half hours.

Ptomaines extracted by Amyl Alcohol and Ether.—By extracting with amyl alcohol and ether, re-solution in alcohol, and then precipitating the solution with basic lead acetate, filtering, freeing from excess of lead, &c., a white substance was ultimately obtained, which reduced iodic acid; precipitated ferric chloride, and corrosive sublimate; iodised hydriodic acid, and gold chloride, but gave no reaction in the cold with sulphuric acid and no precipitate with picric acid, Mayer's reagent, potassio-cadmic iodide, nitrate of silver, and bichromate of potash.

Volatile Products.—He succeeded more than once in separating an alkaloid which was either coniine or some nearly allied volatile product. The possibility of coniine developing in animal substances is evident from the fact of its structure; one molecule of butyric acid, and one molecule of ammonia, with separation of $2H_2O$ might produce it. Thus—

Butyric Acid. Ammonia. Coniine.

$$2C_4H_8O_2+NH_3-2H_2O=C_8H_{15}N.$$

Or again, butyric acid, ammonia, and hydrogen may react thus—

Butyric Acid. Ammonia. Coniine.

$$2C_4H_8O_2+NH_3+2H_2-4H_2O=C_8H_{15}N.$$

Or again, trimethylamine and valerianic acid may react thus—

Valerianic Acid. Trimethylamine. Coniine.

$$C_5H_{10}O_2+C_3H_9N-2H_2O=C_8H_{15}N.$$

Similarly, caproic acid and ammonia (not to mention the reactions of certain amides with nascent hydrogen) may produce coniine; but that any synthesis of coniine is a common occurrence in dead bodies may be denied.

Ptomaines from Fatty Matters.—By washing fatty matters with water acidulated by sulphuric acid, then extracting the solution with ether, first acting on the acid liquid, and then on the same alkalised by baryta, Selmi obtained an alkaline residue of pungent taste, which, when neutralised with acetic acid and dissolved, gave precipitates with tannin, iodine in hydriodic acid, and chloride of platinum and gold, and strongly reduced iodic acid.

Ptomaines containing Arsenic.—Selmi has made the interesting observation that strongly poisonous and crystalline ptomaines, some of which contain arsenic, may be found in the exhumed bodies of men or animals who have died from arsenical poison. In a subject exhumed fourteen days after death, the corpse was well preserved, and a large amount of arsenic was detected. By the search for alkaloids with ether in a liquid made alkaline with baryta, a substance in small quantity was separated which crystallised in needles, and formed crystallisable salts with acids. It gave no precipitate with platinic chloride, save in very concentrated solutions; with sulphuric acid it struck a red colour; with iodic acid, and afterwards with sulphuric acid, free iodine was liberated, and a violet colour produced, which disappeared on neutralisation with sodic carbonate.

Nitric acid coloured it beautifully yellow, and by saturation with caustic potash this colour deepened. Nordhausen sulphuric acid produced only after some time a red colour; iodine in hydriodic acid gave no crystalline product. The quantity of this substance obtained was insufficient for further experiments; but a short time after Selmi was enabled to obtain a larger amount of ptomaines from the body of a man which had been exhumed a month after death. The ptomaine was extracted with ether from an alcoholic extract, dissolved in water, and neutralised by baryta, and subsequently purified and converted into acetate. The solution gave with tannic acid a white precipitate; with iodine in hydriodic acid, a kermes-brown precipitate, gradually disappearing, and furnishing microscopical, colourless, and branched, but no yellow or brown crystals. With platinic chloride it gave no precipitate, but in the course of time yellow crystals appeared, not like those of platinic chloride. Auric chloride gave a yellow precipitate, which was afterwards reduced; mercuric chloride, a white precipitate; potassic bichromate, no precipitate; picric acid, a yellow precipitate, which gradually changed to long crystalline tables of a yellow colour. No iodic acid was liberated, even after the addition of several drops of sulphuric acid, but, on warming, free iodine appeared quickly, and on saturating with sodic bicarbonate, the violet colour disappeared. The substance was intensely poisonous, but it contained no arsenic. Selmi later discovered organic bases containing arsenic in the stomach of a hog, which had been preserved in a solution of arsenious acid. The liquid was first submitted to a distillation in a current of hydrogen; the distillate was alkaline, and when neutralised with HCl, and evaporated to dryness, yielded a white non-deliquescent hydrochlorate in cross-shaped crystals; developing a smell similar to, but not identical with, that of trimethylamine. By oxidising it with nitric acid, taking up the residue with sulphuric acid, reducing the arsenic acid, by means of sulphurous acid, to arsenious acid, and, submitting it to the action of a Marsh's apparatus, arsenic was shown to be present. This body did not precipitate tannic acid; with iodine in hydriodic acid, there was a precipitate of beautiful crystals of a grey colour, and the appearance of iodine; with picric acid, a yellow precipitate which changed to long, yellow, felt-like needles. Platinic chloride gave directly a granular canary-yellow precipitate of microscopic octahedrous; mercuric chloride gave no precipitate.

Professor Ciaccio made some physiological experiments with 24 mgrms. of the substance, and found that it was most intensely poisonous, resembling strychnine in its action. From the solid matter, and also from the liquid which remained in the retort, a fixed arsenical ptomaine (by treatment on the principles previously detailed) was extracted by ether. Its solution in water gave, with tannin, a slowly-separating yellowish precipitate; with iodine in hydriodic acid, a yellowish-red precipitate, and brown drops; with platinic chloride, a non-crystalline yellowish powder; with auric chloride, a yellowish precipitate, which was afterwards reduced. Mercuric chloride and potassio-mercuric iodides gave yellowish white precipitates; potassic bismuthic iodide, an orange-yellow precipitate, changing to red; picric acid, a non-crystalline, and potassium bichromate, a reddish-yellow precipitate. Experiments made on frogs showed that its poisonous action was different to that of the volatile arsines, but was connected with the action of the ordinary ptomaines. The most prominent phenomena were torpor, paralysis, and systolic inactivity of the heart.

Ptomaines are by no means produced solely in the putrefaction of animal substances. Lombroso and Erba first showed that during the putrefaction of maize, a poisonous basic principle was developed, which had a toxic action similar to that of strychnine. The putrid leguminous substances are also likely to produce poisonous bases. It seems reasonable to believe that some of the cases of poisoning from eating meat-pies, sausages, and the like, which have hitherto been referred to diseased meat, or have received no explanation, have been really due to poisoning by ptomaines.

From the preceding sketch it is evident that no single member of the cadaveric alkaloids has been completely studied. What we have hitherto learned concerning them is, for the most part, derived from a study of microscopic films or, at the best, a few milligrammes. There is, therefore, all the uncertainty about the properties of these bodies which is inherent to conclusions based upon reactions on minute quantities, and physiological experiments undertaken with substances the purity of which is doubtful. Nevertheless, the existence of ptomaines may be conceded, and also the fact that some of their reactions and properties resemble such alkaloids as strychnine, morphine, atropine, delphinin, and coniine; but such differences, for the most part, exist that a careful and experienced toxicologist would not be likely to form erroneous conclusions. Attempts have been made to find some general test which would distinguish the ptomaines from the natural alkaloids, but with no complete success as yet. Potassic ferrid-cyanide is very quickly reduced by all ptomaines, and is, therefore, a most useful test. The base is converted into sulphate; a drop of the ferrid-cyanide solution is put into a watch-glass, and the solution of the base added. The mixed liquid is then tested with a ferric salt; if reduction has taken place, the liquid will become Prussian blue in colour. The behaviour of the plant-alkaloids to ferrid-cyanide may be summarised as follows:—

Reducing Potassic Ferrid-cyanide but Slowly.

Hyoscyamine, emetine, igasurine, colchicine, nicotine, apomorphine, aniline, methylamine, paratoluidine, diphenylamine, napthylamine, pyridin, collidin, hydrocollidine, isodipyridine, diallylendiamine, and actonamine.

Reducing Potassic Ferrid-cyanide in a Few Seconds or in a Moment.

Crystallised ergotinine, crystallised aconitine, digitalin, morphine, eserine; fluid hyoscyamine, amorphous aconitine, and amorphous ergotine.

Brouardel and Boutmy* propose to distinguish between the ptomaines and the natural alkaloids by their action on photographic silver bromide paper. The paper is written on by a glass pen dipped in a solution of the base, and the paper is then sheltered from the light. At the end of half an hour the paper is washed with sodic hyposulphite, and then with water; the plant-bases do not blacken, but the ptomaines reduce the silver, and the writing becomes visible. Too much trust, however, must not be placed on a test so recently proposed.

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THE SYNTHESIS OF POISONS BY THE LIVING.

There are several diseases in which the most rational explanation of the symptoms is either that poisons are self-produced, or else that the blood becomes loaded with excrementitious matters. It has, indeed, been asserted recently that toxic principles in minute quantities may be separated from the urine and saliva of healthy persons;* and if this is so, one may readily admit the possibility of the synthesis of toxic substances in abnormal quantity in states of disease. One of the most striking illustrations of this apparent self-poisoning is to be seen in the disease or state of the body termed acætonæmia, or diabetic coma, and uræmia, which so strikingly simulate the action of narcotic poisons. An excellent example of diabetic coma is recorded in the *Lancet*, March 11, 1882, by Dr. Pratt. The case may be detailed in his own words:

> On Wednesday, May 11, 1881, about 10 p.m., I was requested to visit E. R——, just arrived in Newtown. On reaching the house where the patient was staying I found a young girl of about twenty-four years of age, pale and thin, in a semi-conscious state, breathing rapidly and noisily, with a small quick pulse. She was sitting in an arm-chair, and could answer questions, but confusedly and with difficulty.
>
> The history given of her was as follows:—She had arrived here by the 4 p.m. train from Manchester. At the station she had a staggering gait and a confused manner, with saliva here and there on her clothes, and was considered by all who saw her to be drunk. She took the omnibus to the principal hotel, where she asked for a little brandy and water, which was supplied to her. In a short time she fell off her chair in the commercial room of the hotel in what seemed a kind of fit; she was then helped up to a bedroom where she was very sick. All who saw her thought she was intoxicated. After remaining there about four hours, she was requested to seek her relatives. She then left the hotel, with assistance, and was next seen sitting in a doorway. About 9 p.m. she was able to appeal to a woman who came near to take her in, saying that she was very ill, that she had been so for weeks, and that she had been told by a Manchester medical man that she was suffering from diabetes. The woman believed her story, took her in, and sent for a police officer, who managed to get at the names of her relatives. These, being communicated with, came to her at once and sent for me.

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* That the saliva of a healthy person contains any poisonous principle is doubtful.

I found E. R—— in the condition described. She was not drunk, for there was no tremulousness of hands or tongue, no nonsense talked when she was roused to consciousness, and her countenance was not that of a drunkard. She was not apoplectic, for there was no paralysis. There was no history or appearance of injury. I thought it uræmia. I ordered her to be taken at once to her aunt's, about half a mile off. I accompanied her thither in the conveyance, and saw her safe in bed. Even as I left the unconscious state was deepening.

Next morning, about 9 a.m., I again saw E. R——. She had passed a restless night, and was now almost quite unconscious, only answering "Yes" or "No" when shouted to. The pupils were dilated, and the conjunctiva insensible; pulse 130, small; respiration rapid and noisy. On auscultation, the lungs were found to be without disease, and the heart's sounds very clear and normal. In the night time she had passed urine very freely, and had got out of bed herself to do so. The urine contained about one-eighth of albumen, and was loaded with sugar. At 3 p.m. she was quite insensible; pulse feeble; extremities cold and dusky; respiration and pupils as before. She could still swallow, though quite unconsciously. At 7 p.m. she was *in articulo mortis*, and died comatose at 8 p.m., twenty-two hours after I first saw her. No *post-mortem* examination was permitted.

Here we have all the symptoms of a narcotic poison—first, the mental confusion; next, the drowsiness; and, lastly, the fatal coma.* In death from uræmic poisoning, the same sort of coma may end the scene; but, as a rule, convulsions precede the narcosis, although not always witnessed, for the convulsions of uræmia, as well as those of epilepsy, may take place in the night, or in secluded places, and the individual be found in a deep sleep—without any history. Cases of this kind are so frequent that there is scarcely any medical man of experience who has not met with them. A few years ago a personal friend of my own went to bed in apparently perfect health and spirits, but was found the next morning in a deep coma, which was fatal in about twenty-four hours. The autopsy revealed no lesion whatever; there was neither cerebral effusion, nor disease of any important organs. There was no suspicion of suicide; and it was the opinion of the physicians in attendance that the deceased had had an epileptic fit, which had been followed by coma. Allowing this explanation to be correct, one cannot help here suggesting the synthesis in the body of a narcotic poison. This interesting and forensically important subject seems to demand more attention and investigation by the physician, the physiologist, and the chemist, than have hitherto been given to it.

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* See also Southey, *Lancet*, Feb. 8, 1879; Elliott, *ib.*, March 22, 1879; and "Acetonæmia," by B. Fisher, *Brit. Med. Journal*, Jan. 18, 1878.

II.—POISONING BY PUTRID OR CHANGED FOOD—SAUSAGE POISONING.

The various instances of poisoning which occur from time to time in every European country, and are referable to changes or conditions of food, have now for many years received a considerable degree of attention—the subject still remains most obscure, but from a number of circumstances it is probable that the cases all fall under one of the following heads :

1. Food contaminated with zymotic poison.
2. Meat of a deceased animal, which, when eaten, sows, as it were, in the person of the individual eating it, a living germ, which, by its multiplication, induces an illness.
3. Trichinosis.
4. Ergotism (see p. 422).
5. The production of a ptomaine by some peculiar decomposition of albuminous substances.

1. *Food Contaminated by a Zymotic Poison.*

In India, in 1871, some rice contaminated with the cholera poison propagated the disease to seventy-three persons*

Investigations on the summer-diarrhœa of this country have established its intensely infectious character. Dr. Wm. Johnstone,† in his prolonged microscopical examination of the excreta, himself acquired this affection no less than five times. Hence, it is evident that, when diarrhœa is epidemic, dishes and articles of food may be accidentally contaminated through uncleanly habits, and thus a very complete imitation of irritant poisoning be produced.

2. *Certain Meat (probably of a Diseased Animal) may sow in the Person Eating it a Germ, which, by its Division and Multiplication, causes Illness.*

The best example of this class are shown in the poisonings which occurred at Welbeck and at Nottingham in 1880, and were investigated very completely by Dr. Ballard and others connected with the Local Government Board.‡ On the 15th, 16th, 17th, 18th, and 19th of June,

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* See Author's *Dictionary of Hygiène*, art. "Cholera."

† *Lancet*, Sept. 21 and 28, 1878.

‡ "On an Acute Specific Disease characterised by a peculiar Diarrhœa Epidemic among Persons who had partaken of Refreshments provided at a Sale on the Duke of Portland's Estate at Welbeck," by Dr. Ballard. "On a Series of

1880, was held an extensive sale of timber on the estate of the Duke of Portland, at Welbeck, Notts. On each day a large number of people partook of refreshments, consisting of cold boiled ham, roasted beef, and other articles, and of those who ate a large number were taken ill. Dr. Ballard was able to obtain a more or less complete record of seventy-two cases. On the other hand, an unknown but still large number escaped illness altogether. The cause of the illness was traced by a considerable mass of evidence to one or more hams eaten as sandwiches. Of the seventy-two who suffered, sixty-five were males and only seven females; some were attacked severely, and some slightly; four died, and coroner's inquests were held on two as to the cause of death. A period of incubation preceded the illness, in fifty-one cases where this could be accurately determined; it was twelve hours or less in five cases; between twelve and thirty-six hours in thirty-four cases; between thirty-six and forty-eight hours in eight cases; and later than this only in four cases.

In many cases the first definite symptoms occurred suddenly, and evidently unexpectedly, but in some cases there were observed during the incubation, more or less feeling of languor or ill-health, loss of appetite, nausea, or fugitive griping pains in the belly. In about one-third of the cases, the first definite symptom was a sense of chilliness, usually with rigors or trembling, and in one case accompanied by dyspnœa. In a few cases the premonitory symptoms were giddiness with faintness, sometimes accompanied by a cold sweat and tottering. In others, the first symptoms were headache or pain somewhere in the front of the body—*e.g.*, in the chest, or in the back between the shoulders, or in the abdomen, to which part the pain, wherever it might have commenced, subsequently extended. In one case, the first symptoms noticed was a difficulty in swallowing, in two cases it was intense thirst, but, however the attack may have commenced, it was usually not long before pain in the abdomen, diarrhœa, and vomiting came on, diarrhœa being of more certain occurrence than vomiting. Pain, in several cases, commenced in the chest or between the shoulders, and extended first to the upper, and then to the lower part of the abdomen. It was usually very severe indeed, quickly producing prostration or faintness with cold sweats, and was variously described as "crampy," "burning," "tearing," &c. The diarrhœal discharges were, in some cases, quite unrestrainable, and, where a description of them could be obtained, were said to have been exceedingly offensive, and usually of a dark colour. Muscular weakness was an early and very remarkable symptom in nearly

Cases of Acute Specific Disease (similar to that observed in the Welbeck outbreak) following the eating of Hot-baked Pork purchased at a shop in Nottingham," by Dr. Ballard.—*Supp. to Tenth Ann. Report of the Local Govt. Board for* 1880.

all cases, and in many was so great that the patient could only stand by holding on to something. Headache, sometimes severe, was a common and early symptom, and in most cases there was thirst, often intense and most distressing. The tongue, when observed, was described usually as thickly coated with a brown velvety fur, but red at the tip and edges. In the early stage the skin was often cold to the touch; but afterwards some fever set in, the temperature rising to 101°, 103°, and 104°. In a few severe cases where the skin was actually cold, the patient complained of heat, insisted on throwing off the bedclothes, and was very restless. The pulse, in the height of the illness, became rapid, counting in some cases 100 to 128. The above were the symptoms most frequently noted. Other symptoms occurred, however, some in a few instances, and some in only solitary cases—such as excessive sweating; cramps in the legs, or in both legs, and arms; convulsive flexion of the hands or fingers; muscular twitchings of the face, shoulders, or hands; aching pain in the shoulders, joints, or extremities; a sense of stiffness of the joints, prickling, or tingling, or numbness of the hands, lasting far into convalescence. Again, in some cases, there was a sense of general compression of the skin, together with drowsiness, hallucinations, imperfection of vision, and intolerance of light. In three cases (one, that of a medical man), there was observed yellowness of the skin, either general or confined to that of the face and eyes. In one case, at a later stage of illness, there was some pulmonary congestion, and an attack of what was regarded as gout. In the fatal cases, death was preceded by collapse like that of cholera, coldness of the surface, pinched features, sunken eyes, and blueness of the fingers and toes. The debility of convalescence was in nearly all cases protracted by several weeks. The mildest cases were characterised usually by little remarkable beyond the following symptoms:—Abdominal pains, vomiting, diarrhœa, thirst, headache, muscular weakness, any one or two of which might be absent. In three out of the four fatal cases *post-mortem* examinations were made, but in only one was the examination at all thorough. In all, the mucous membrane of the stomach was highly congested, and the intestines in two were also in the same state; the lungs in one case were soft and congested from pneumonia of the dying; in another they were not examined; and in a third case there was congestion of the left lung. The kidneys, or portions of them, from a severe case, were examined microscopically by Dr. Klein, who discovered evidence of parenchymatous inflammation, and a plugging of the afferent arterioles and capillaries of the malpighian corpuscles, with emboli formed of masses of bacilli. Some of the glomeruli had undergone a total or partial obliteration, owing to a degeneration, at first hyaline, afterwards fibrous, of the capillaries. Dr. Klein describes this degeneration as of exactly the same nature as that occurring in scarlatinal nephritis. The bacilli found were in the state of spore-formation.

Some of the ham was obtained and found by Dr. Klein to contain a species of bacillus with sporules of the same. The bacillus threads and sporules were in connection with the muscular fibre and in the intermuscular tissue. Dr. Klein made various experiments on animals with the ham, and also with some of the bacillus-producing material after cultivation in an incubator. In all but a few instances this produced in mice, rats, dogs, guinea-pigs, and other animals experimented upon, disease. The morbid condition produced in the animals, and found on *post-mortem* examination, was most uniformly pneumonia; in one instance, pleuritis or pulmonary hyperæmia; in some, hæmorrhage into the pulmonary tissue was observed. In one there was hæmorrhage into the tissue of the liver, and the organ was found enlarged. In some the spleen was found enlarged, and congested. In three instances peritonitis, slight or severe, was found. Two dogs fed and inoculated with the cooked ham, and killed on the eighth day (one having suffered from colic on the first day of the feeding), exhibited after death evidence of severe desquamative hyperæmia, or inflammation of the stomach and intestines, the contents of which contained bacilli and a few pus corpuscles. Bacilli were found in the blood of two white mice which died twenty-four hours after being fed and inoculated with bacteria from the raw ham ; but no bacilli were discoverable in the blood of two other mice inoculated with this blood, although, when they were killed on the second and third days respectively, they were both found to have severe pneumonia, with enlarged liver and enlarged congested spleen. Nor were bacilli found in the blood of four other animals in which they were sought for after death.

The Nottingham case was almost as remarkable. The members of five different households, fifteen in all, were taken ill on February 11th and 12th. All the persons had eaten pork purchased at a particular shop, and one of the sufferers died. The symptoms differed in no essential respect from those already detailed in the Welbeck poisonings. The illness lasted several days, and left behind much muscular weakness. An abstract of the symptoms suffered by the man who died is as follows :—

J. C., aged 23, a painter by trade, ate some pork on the evening of Friday, February 11. He passed a good night, and went to his work at 8.30 a.m., as usual. At 2 p.m., (which was probably about eighteen hours after eating the pork) he complained of feeling sick, and was purged all the afternoon, but he passed a good night. The next day he could eat nothing, was constantly purged, and vomited, rejecting all liquids ; there was great muscular weakness with a feeling of chilliness; he passed a bad night, and the next day (Monday) complained of severe pain in the abdomen with headache. The vomitting and diarrhœa continued. His skin was hot, the abdomen tender, and the arms and legs bent and twitching. Later in the day, the face was swollen, the eyes puffy, the skin was livid in patches, and hot, and the pulse almost imperceptible; the legs and arms were constantly twitching, and he repeatedly and suddenly threw himself from side to side "as if electricity had been applied;" he then became delirious. On Tuesday he died at 2 p.m., about three days and eighteen hours after eating the pork.

Post-mortem Examination.—The lungs were deeply engorged and non-crepitant; very little liquid followed the knife on section, but a little dark bloody fluid could be expressed by squeezing. There was redness of the mucous membrane of the stomach in patches, and also some slight redness of the jejunum; the kidneys were apparently healthy. The spleen was small and shrivelled, and the tissue readily broke down on pressure. Dr. Klein made microscopical researches in the kidneys, blood, liver, mesentery, spleen, and other parts. His results are summarised by Dr. Ballard, thus:—

1. Bacilli, similar to those discovered in the Welbeck inquiry, were found in varying numbers in the blood, pericardial fluid, juice expressed from the lung, in the air vesicles and in the blood-vessels of the lung, in the tissues of the stomach and ileum, in the spleen within and around its large vessels, and in and around the vessels of the kidney, and in the connective tissue between the tubuli of the renal cortex.

2. The capillary vessels of the glomeruli of many of the Malpighian corpuscles of the kidney being degenerated into hyaline or fibrous bands, the nuclei of the glomeruli being increased ("glomerulo-nephrits,"—some of the tubuli contorti contained extravasated blood, others of them hyaline casts.

3. There were hæmorrhagic infarctions of the lung tissue, and bacilli were found with or without spores amongst the blood, filling the air vesicles and in the blood vessels.

4. Inflammation of Peyer's glands, of the small intestine, and a few baccilli in the submucous tissue.

5. In the liver, slight interstitial hepatitis.

Guinea-pigs inoculated with the blood, pericardial exudation, and lung juice, became diseased. Six out of ten animals inoculated died spontaneously, and four were killed. Pneumonia in two, accompanied by pulmonary hæmorrhage, was found after death, and in eight of the ten there was peritonitis; in four pleuritis also; and in two, in addition to pneumonia, there was enlargement of the liver and spleen. In two guinea-pigs inoculated with the blood, a tumour containing purulent matter developed at the seat of inoculation. Similar results followed the inoculation of material obtained by cultivation of the blood and lung juice in the incubator. Bacilli were found in the blood and exudations of some of the above inoculated animals, as well as in the purulent matter in the tumours found in two of them, as above described, at the seat of inoculation.

3. *Trichinosis.*

The trichina spiralis is a minute nematode helminthe, in the shape of a little worm, the body being round and filiform. The male in its sexually mature state measures only $\frac{1}{18}$ inch, while the female measures $1/8$ inch. The mode of reproduction is viviparous, and most females contain from three to five hundred ova. Their power of multiplication is marvellous ; in six days the female parasites will contain perfectly developed and free embryos in the interior, and these pass by the genital outlet, which is placed far forward at about the end of the first fifth of the long diameter of the body ; the new-born young commence almost at once their wandering. They penetrate the walls of the intestines, and pass directly through the abdominal cavity into the muscles of their bearers, where, if conditions are favourable, they become encysted, the cysts appearing like small round dots, granules, or vesicles, quite distinct from the red muscle; sometimes the cyst calcifies. In the interior of the cyst the trichina is rolled up in a spiral form (Fig. 16). The next figure (Fig. 17) shows it partially uncoiled, removed from the cyst, and further magnified.

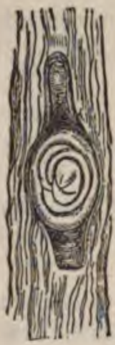

Fig. 16.—(After Virchow).

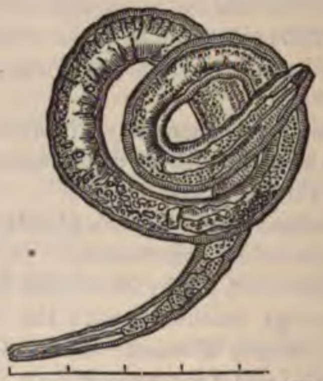

Fig. 17.—100th of an inch × 300.

Trichinæ have been found in swine, dogs, badgers, cats, horses, oxen, sheep, eels, pigeons, and moles.

The symptoms of trichinosis can hardly be confused with those of poison, but the disease has often been mistaken for typhoid fever ; there is a certain marked interval between the ingestion of the food and the development of the illness; there is no case of trichinosis on record in which the symptoms may be described as immediate; in all, one or even several days have elapsed before the person became affected. The usual course is one of gradual development, there is weariness, loss of appetite, and eventually febrile phenomena; then follows pain in the muscles, which may simulate rheumatism, and in fatal cases may be very severe; the cause of death is various, some dying from pneumonia, others from exhaustion.

5. *The Production of a Ptomaine or some Chemical Poison in Albuminous Substances.*

Several cases of sausage poisoning belong almost beyond a doubt to this class—for example, the remarkable case recorded by Dr. Ballard.* A gardener, aged forty-two, purchased, on March 13, 1881, half a pound of sausages; the sausages were of a large description, each weighing several pounds, and similar to those commonly sold under the name of "German sausage." Each sausage was imported, packed in a cylinder of tinned iron, the interval between the sausage and the cylinder being filled with melted fat; the covers of the cylinder were soldered down. The sausages were said to have been make of beef. About 11 a. m., he ate the half pound of sausages, and at 11.45 was found by his son lying on a truss of hay very ill, suffering from great abdominal pain; he had vomited, and was purged, his head was hot, his face flushed, but the feet were cold, and he complained alternately of heat and chilliness. He was carried home in the afternoon, and continued during the evening and night to be purged and to vomit. A medical man saw him in the course of the evening, but considered that he was suffering from bronchitis; he had at the time a pain in the chest and cough, and the sputa was rusty and glutinous. The man died on March 21, eight days after eating the sausage, the breathing becoming more and more difficult. No coroner's inquest was held. Part of the sausage was obtained and submitted to Dr. Klein, who gave the following report of the experiments which he made:—

> The sausages were marked 1, 2, 3, 4, 5, 6, 7, 8, 9. No. 9 was the remains of the sausage which the gardener had partaken of; these sausages were used for feeding animals—rabbits and mice; while some samples (Nos. 7 and 5) proved innocuous, others (Nos. 6 and 8) were very poisonous. With No. 6 were fed twelve mice and four rabbits; of the mice five died spontaneously, three after twenty-

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* On a case of "Sausage Poisoning" which occurred at Arlford, near Chester.—*Supplement to Eleventh Annual Report of the Local Government Board for* 1881.

four hours, and two after sixty hours; three were killed while ill, and four escaped illness. Of the rabbits, one died spontaneously during the first day, one during the second day, and two others were killed while ill. With No. 8 were fed four mice, of these one died spontaneously after eight hours, one after thirty hours, and the other two after twenty-four hours. On March 26, four rabbits and four mice were fed with No. 9, (the sausage the man had partaken of), and none of these animals suffered illness; on May 2, however, four mice were fed with it and became ill, but they had recovered perfectly on the fifth day. In all instances when the animal became ill, the illness showed itself very soon after the feeding—viz., from a quarter of an hour to several hours, the animals became very quiet, and in some instances, especially in the rabbits, there was vomiting a quarter of an hour after feeding. They did not take their food, and did not care to move, their faces became pinched, and their eyes small. In the case of the mice, their coats became very rough; this state soon grew worse, the animals becoming comatose. The temperature rapidly sank, and the animals soon died; in some cases they lingered on for several days, recovered slightly, took food again, and became a little more lively; but when killed they showed the same *post-mortem* appearances as those that died spontaneously, only in a milder degree.

On *post-mortem* examination, the appearances found were hæmorrhages in the stomach, congestion of the lungs, enlarged kidneys, the cortex of the organ being pale, the medulla hyperæmic. On microscopical examination of the kidney, the important fact was ascertained that most of the urinary tubules contained casts, that many malpighian corpuscles and the tissues surrounding them were in a state of disintegration, without, however, there being present any inflammatory cells (pus corpuscles), so that the disintegration was evidently due to the direct result of some destructive agency acting in the vessels of the glomeruli of the malphigian corpuscles. The result of these experiments was, then, in a high degree indicative of the presence in the sausages of some chemical poison, for the sudden illness following shortly after the feeding, the vomiting, the hæmorrhage in the stomach, and the condition of the kidney are just such as are compatible only with that assumption. Consequently part of sausage No. 6, which had proved very poisonous to mice and rabbits, was forwarded to Dr. Dupré, and he prepared from it (*a.*) a cold alcoholic extract, and (*b.*) an alkaloid in an impure state. Experiments, however, made by feeding and inoculation with either of these on a dog, two mice, and two rabbits, did not produce any symptom of illness.

It is to be noted that whatever poison the sausage contained must have been distributed unequally through the mass, and it is possible that the chemical expert, although he had part of a sausage which was poisonous, may not have had a part with the particular poison in it. The state of the kidneys in the mice fully bears out Dr. Ballard's suggestion, that the pneumonia of the patient was probably dependent on the renal congestion. At the same time, the case affords grounds for some painful suspicion that a few of the cases of pneumonia returned from country districts, may not be pneumonia, but the result of poisoning, for the case quoted would certainly be returned as death from one form or other of respiratory affection.

A series of cases may be picked out from the accounts of sausage poisoning in Germany, all of which evidently depend upon a poison producing the same symptoms, and the essentially distinctive mark of which is extreme dryness of the skin and mucous membranes, dilatation of the pupil, and paralysis of the upper eyelids (ptosis). In an uncertain time after eating sausages or some form of meat, from one to twenty-four hours, there is a general feeling of uneasiness, a sense of weight about the stomach, nausea, and soon afterwards vomiting, and very often diarrhœa. The diarrhœa is not severe, never assumes a choleraic form, and is unaccompanied by cramps in the muscles. After a considerable interval there is marked dryness of the mucous membrane (a symptom which never fails), the tongue, pharynx, and the mouth generally seem actually destitute of secretion; there is also an absence of perspiration; the nasal mucous membrane participates in this unnatural want of secretion; the very tears are dried up. In a case related by Kraatzer,* the patient, losing a son, was much troubled, but wept no tear. This dryness leads to changes in the mucous membrane; it shrivels, and partly desquamates, aphthous swellings may occur, and a diffuse redness and diphtheritic-like patches have been noticed. There is obstinate constipation, probably from a dryness of the mucous lining of the intestines. The breath has an unpleasant odour, there is often a croupy cough, the urinary secretion alone is not decreased but rather augmented. Swallowing may be so difficult as to rise to the grade of aphagia, and the tongue cannot be manipulated properly, so that the speech may be almost unintelligible. At the same time marked symptoms of the motor-nerves of the face are present, the patient's sight is disturbed, he sees colours or sparks before his eyes; in a few cases there has been transitory blindness, in others diplopia. The pupil in nearly all the cases has been dilated, also in exceptional instances it has been contracted. The *lavator palpebrae superioris* is paralysed, and the resulting ptosis completes the picture. Consciousness remains intact almost to death; there is excessive weakness of the muscles, perhaps from a general paresis. If the patient lives long enough, he gets wretchedly thin, and dies from marasmus. In more rapidly fatal cases, death follows from respiratory paralysis, with or without convulsions.

The *post-mortem appearances* which have been observed are—the mucous membranes of the mouth, gullet, and throat are white, hard, and parchment-like; that of the stomach is more or less injected with numerous hæmorrhages; the kidneys are somewhat congested, with some effusion of blood in the tubuli; the spleen is large and very full of blood, and the lungs are often œdematous, pneumonic, and bronchitic.

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* Quoted by Husemann. *Vergiftung durch Wurstgift* (Maschka's *Handbuch*).

PART VII.—THE OXALIC ACID GROUP OF POISONS.

Oxalic acid is very widely distributed both in the free state and in combination with bases throughout the vegetable kingdom, and it also occurs in the animal kingdom. In combination with potash it is found in the *Geranium acetosum* (L.), *Spinacia oleracea* (L.), *Phytolacca decandra* (L.), *Rheum palmatum* (L.), *Rumex acetosa*, *Atropa belladonna*, and several others; in combination with soda in different species of *Salsola* and *Salicornia;* and in combination with lime in most plants, especially in the roots and bark. Many lichens contain half their weight of calcic oxalate, and oxalic acid, either free or combined, is (according to the observations of Hamlet and Plowright)* present in all mature non-microscopic fungi. Crystals of oxalate of lime may be frequently seen by the aid of the microscope in the cells of the plants. According to Schmidt† this crystallisation only takes place in the fully mature cell, for in actively growing cells the oxalate of lime is entirely dissolved by the albumen of the plant.

In the animal kingdom oxalic acid is always present in the intestinal contents of the caterpillar. In combination with lime it is constantly found in the allantois liquor of the cow, the urine of man, swine, horses, and cats. With regard to human urine, the presence or absence of oxalate of lime greatly depends upon the diet, and also upon the individual, some persons almost invariably secreting oxalates whatever their food may be.

Oxalic Acid, $H_2C_2O_4 2H_2O$(90+36), specific gravity 1·64, occurs in commerce in prismatic crystals, very similar to, and liable to be mistaken for, either magnesic or zincic sulphates. The crystals are intensely acid, easily soluble in water (1 part requiring at 14·5° 10·46 parts of water); they are also soluble in 2½ parts of cold, and readily in boiling, alcohol. Oxalic acid is slightly soluble in cold absolute ether; but ether, although extracting most organic acids from an aqueous solution, will not extract oxalic acid.

Oxalic acid sublimes slowly at 100°, but rapidly and completely at 150°; the best means of obtaining the pure anhydride, is to put a sufficient quantity of the acid into a strong flask, clamp it by suitable connections to the mercury pump described at page 53, and sublime in a vacuum; in this way a sufficient quantity may be sublimed a little above 100°. It is well to remember, not only its low subliming temperature, but also that an aqueous solution, if kept at 100°, loses acid; hence all evaporating or heating operations must not exceed 98°, or there will be some loss. The effect of heat is first to drive off water, then, if continued up to about 190°, there is decomposition into carbon oxide, dioxide, water, and formic acid; the two reactions occurring simultaneously—

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* *Chem. News*, vol. xxxvi., p. 93.

† *Ann. Chem. Pharm.* vol. lxi., p. 297.

$$C_2H_2O_4=CO_2+CO+H_2O.$$
$$C_2H_2O_4=CO_2+CH_2O_2.$$

Heated with sulphuric acid to 110°, the following decomposition takes place:—

$$H_2C_2O_4=H_2O+CO_2+CO.$$

Oxalic acid decomposes fluor spar, the phosphates of iron, silver, zinc, copper, and the arseniates of iron, silver, and copper. It may be used to separate the sulphides of iron and manganese from the sulphides of zinc, cadmium, uranium, cobalt, mercury, and copper—dissolving the former, not the latter. Many minerals and other substances are also attacked by this acid.

If a solution of oxalic acid in water is boiled with ammonio or sodio terchloride of gold (avoiding direct exposure to light) the gold is precipitated—

$$2AuCl_3+3H_2C_2O_4=6CO_2+6HCl+Au_2.$$

When black oxide of manganese (free from carbonate) is mixed with an oxalate, and treated with dilute sulphuric acid, the oxalic acid is decomposed, and carbon dioxide evolved—

$$MnO_2+H_2C_2O_4+H_2SO_4=NnSO_4+2H_2O+2CO_2.$$

A similar reaction occurs with permanganate of potash.

If to a solution of oxalic acid, which may be neutralised with an alkali, or may contain free acetic acid, a solution of acetate of lime be added, oxalate of lime is thrown down. This salt, important in an analytical point of view, it will be well to describe.

Oxalate of Lime ($CaC_2O_4H_2O$), 1 part = ·863 crystallised oxalic acid. This is the salt which the analyst obtains for the quantitative estimation of lime or oxalic acid; it is not identical with that occurring in the vegetable kingdom, the latter containing $3H_2O$. Oxalate of lime cannot be precipitated for quantitative purposes from solutions containing chromium, aluminium, or ferric iron, since somewhat soluble salts are formed. It dissolves in solutions of magnesium and manganese,[*] and citrate of soda, and is also decomposed by boiling with solutions of copper, silver, lead, cadmium, zinc, nickel, cobalt, strontium, or barium. It is insoluble in solutions of chlorides of the alkalies and alkaline earths, and in water, in alkaline solutions, or in acetic acid; and is soluble in mineral acid only when the acid is strong and in considerable excess. It is unalterable in the air, and at 100°. When carefully and slowly ignited it may be wholly converted into carbonate of lime; if the heat is not properly managed (that is, if excessive), caustic lime may be formed in greater or smaller quantity.

Use in the Arts.—Oxalic acid is chiefly used by dyers and calico-printers, but also by curriers and harness-makers for cleaning leather, by marble masons for removing iron stains, by workers in straw for bleaching, and it is applied to various household purposes,[†] such as the whitening of boards, the removing of iron-mould from linen, &c. The hydropotassic oxalate (binoxalate of potash) under the popular names of "*essential salt of lemons,*" and salts of sorrel, is used for scouring metals and for removing ink-stains from linen.

Hydropotassic Oxalate, Binoxalate of Potash, $KHC_2O_4(H_2O)$, is a white salt, acid in reaction, soluble in water, and insoluble in alcohol. Heated on platinum foil it leaves potassic carbonate, which may be recognised by the usual tests. Its aqueous solution gives, with a solution of acetate or sulphate of lime, a precipitate of calcic oxalate insoluble in acetic acid.

Statistics.—Poisoning by oxalic acid is more frequent in England than in any other European country. In the five years 1875–80, there were registered in England 74 deaths from oxalic acid—of these 65, or 87·8 per cent., were suicidal, the remainder accidental. Of the 74 deaths, 41 were males and 33 females—1 was a child between 5 and 10 years of age, 3 were between 15 and 20, 7 between 20 and 25, 6 between 25 and 35, 39 between 35 and 55, and 18 between 55 and 75.

Fatal Dose.—The smallest dose of oxalic acid known to have destroyed life is, according to Dr. Taylor, 3·88 grms. (60 grains); but recovery has taken place, on prompt administration of remedies, after eight times this quantity had been swallowed.

With regard to oxalate of soda, or binoxalate of potash, 14·2 grms. (half an ounce) have been taken without fatal result, although the symptoms were very serious; and it may be held that about that quantity would usually cause death. Oxalic acid is not used in medicine.

[*] But it is reprecipitated unaltered by excess of alkaline oxalate.

[†] A "Liquid Blue," used for laundry purposes, contains much free oxalic acid.

Effects of Oxalic Acid and Oxalates on Animals.—The first cases of poisoning by oxalic acid occurred early in the nineteenth century, a little more than fifty years after its discovery. Thompson * was the first who attempted by experiment on animal life to elucidate the action of the poison; he noted the caustic action on the stomach, and the effects on the heart and nervous system, which he attributed simply to the local injury through the sympathetic nerves. Orfila † was the next who took the matter up, and he made several experiments; but it was Robert Christison ‡ who distinctly recognised the important fact that oxalic acid was toxic, quite apart from any local effects, and that the soluble oxalate, such as sodic and potassic oxalates, were violent poisons.

Kobert and Küssner § made, two or three years ago, some very extended researches on the effects of sodic oxalate on rabbits, cats, dogs, guinea-pigs, hedgehogs, frogs, &c.,—the chief results of which are as follows:—On injection of sodic oxalate solution in moderate doses into the circulation, the heart's action, and, therefore, the pulse becomes arhythmic; and a dicrotic or tricrotic condition of the pulse may last even half a day, while at the same time the frequency may be uninfluenced. The blood-pressure also with moderate doses is normal, and with small atoxic doses there is no slowing of the respiration. On the other hand, toxic doses paralyse the respiratory apparatus, and the animal dies asphyxiated. With chronic and subacute poisoning the respiration becomes slower and slower, and then ceases from paralysis of the respiratory muscles. The first sign of poisoning, whether acute or chronic, is a sleepy condition; dogs lie quiet, making now and then a noise as if dreaming, mechanical irritations are responded to with dullness. The hind extremities become weak, and then the fore. This paresis of the hind extremities, deepening into complete paralysis, was very constant and striking. Take, for example, from the paper (*Op. cit.*) the experiment in which a large cat received in six days five subcutaneous injections of 5 cc. of a solution of sodic oxalate (strength 1:30), equalling ·16 grm.; the cat died, as it were, gradually from behind forwards, so that on the sixth day the hinder extremities were fully motionless, and without feeling. The heart beat strongly. The temperature of the poisoned animal always sink below the normal condition. Convulsions in acute poisoning are common, in chronic quite absent; when present in acute poisoning, they are tetanic or strychnic-like. In all the experiments of

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* *Lond. Med. Rep.*, vol. iii., p. 382.

† *Traité de Toxicologie.*

‡ *Edin. Med. and Surg. Journ.*, 1823.

§ *Exper. Wirkungen der Oxalsäure, Virch. Archiv*, Bd. lxxvii., S. 209.

Kobert and Küssner, lethal doses of soluble oxalates caused the appearance of sugar in the urine.

J. Uppmain* made forty-nine experiments on dogs, in which he administered relatively large doses by the stomach; no poisonous effect followed. Emil Pfeiffer† gave a dog in three successive days ·2, ·5, and lastly 1 grm. oxalic acid with meat, but no symptoms resulted. Yet that oxalic acid, as sodic oxalate, is poisonous to dogs, if it once gets into the circulation, cannot be disputed. The accepted explanation is that the large amount of lime phosphates in the digestive canal of dogs is decomposed by oxalic acid, and the harmless lime oxalate formed.

Oxalic acid is absorbed into the blood, and leeches have been known to die after their application to a person who had taken a large dose. Thus Christison‡ quotes a case related by Dr. Arrowsmith, in which this occurred:—"They were healthy, and fastened immediately; on looking at them a few minutes after, I remarked that they did not seem to fill, and on touching one it felt hard, and instantly fell off motionless and dead; the others were in the same state. They had all bitten, and the marks were conspicuous, but they had drawn scarcely any blood. They were applied about six hours after the acid had been taken."

Effects of Vaporised Oxalic Acid.—Eulenberg has experimented by pigeons on the action of oxalic acid when breathed. In one of his experiments, ·75 grms. of the acid was volatilised into a glass shade, in which a pigeon had been placed; after this had been done five times in two minutes, there was uneasiness, shaking of the head, and cough, with increased mucous secretion of the nasal membrane. On continuing the transmission of the vapour, after eight minutes there was again restlessness, shaking of the head, and cough; after eleven minutes the bird fell and was convulsed. On discontinuing the sublimation, it got up and moved freely, but showed respiratory irritation. On the second day after the experiment, it was observed that the bird's note was hoarse, on the fourth day there was slowness of the heart's action and refusal of food, and on the sixth day the bird was found dead. Examination after death showed slight injection of the cerebral membranes; the cellular tissue in the neighbourhood of the trachea contained in certain places extravasations of blood, varying from the size of a pea to that of a penny; the mucous membrane of the larynx and trachea was swollen and covered with a thick croupous layer; the lungs were partially hepatised and the plura thickened; the crop as well as the true intestines still contained some food.§

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* *Allg. Med. Central Ztg.*, 1877.

† *Archiv der Pharm.* (3 R.), Bd. xiii, S. 544, 1878.

‡ "Treatise on Poisons."

§ *Gewerbe Hygiène*, p. 423.

The Effects of Oxalic Acid and Hydropotassic Oxalate on Man.—The cases of oxalic poisoning have been invariably due to either oxalic acid or hydropotassic oxalate, the neutral sodic or potassic oxalates having hitherto in no instance been taken. The symptoms, and even the locally destructive action of oxalic acid and the acid oxalate, are so similar that neither from clinical nor *post-mortem* signs could they be differentiated by any one not having a previous knowledge of the case.

The external application of oxalic acid does not appear to cause illness; workmen engaged in trades requiring the constant use of the acid often have the nails white, opaque and brittle; but no direct injury to health is on record.

A large dose of either causes a local and a remote effect; the local is very similar to that already described as belonging to the mineral acids—*i.e.*, more or less destructive of the mucous membranes with which the acid comes in contact. The remote effects may only be developed after a little; they consist essentially of a profound influence on the nervous system. Though more than 120 cases of oxalic acid poisoning have occurred since Christison wrote his treatise; his graphic description still holds good. "If," says he, "a person immediately after swallowing a solution of crystalline salt, which tasted purely and strongly acid, is attacked with burning in the throat, then with burning in the stomach, vomiting, particularly of bloody matter, imperceptible pulse, and excessive languor, and dies in half an hour, or still more, in twenty, fifteen, or ten minutes, I do not know any fallacy which can interfere with the conclusion that oxalic acid was the cause of death. No parallel disease begins so abruptly, and terminates so soon; and no other crystalline poison has the same effect." The local action is that of a solvent on the mucous tissues. If from 10 to 30 grms. are swallowed, dissolved in water, there is an immediate sour taste, pain, burning in the stomach, and vomiting The vomit may be colourless, greenish, or black, and very acid; but there is a considerable variety in the symptoms. The variations may be partly explained by saying that, in one class of cases, the remote or true toxic effects of the poison predominate; in a second, the local and the nervous are equally divided; while in a third, the local effects seem alone to give rise to symptoms.

In a case at Guy's Hospital, in 1842, there was no pain, but vomiting and collapse. In another case which occurred in 1870, a male (aged forty-eight) took 10·4 grms. (162 grains); he had threatening collapse, cold sweats, white and red patches on the tongue and pharynx, difficulty in swallowing, and contracted pupils. Blood was effused from the mouth and anus; on the following day there were convulsions, coma, and death, thirty-six hours after taking the poison. In another case, there was rapid loss of consciousness and coma, followed by death in five hours. Death may be very rapid—*e.g.*, in one case (*Med. Times and Gaz.*, 1868) it took place in ten minutes; there was bleeding from the stomach, which doubtless accelerated the fatal result. Orfila has recorded a death almost as rapid from the acid oxalate of potash; a woman took 15 grms.; there was no vomiting, but she suffered from fearful cramps, and death ensued in fifteen minutes. In another case, also recorded by Orfila, there was marked slowing of the pulse, and soporific tendencies. With both oxalic acid and the acid oxalate of potash, certain nervous and other sequelæ are more or less constant, always provided time is given for their development. From the experiments already detailed on animals, one would expect some paresis of the lower extremities, but this has not been observed in man. There is more or less inflammation of the stomach, and often peritonitis; in one case (*Brit. Med. Journal,* 1873) there was cystitis and acute congestion of the kidneys with albuminuria.

In two cases quoted by Taylor, there was a temporary loss or enfeebleness of voice; in one of the two, the aphonia lasted for eight days. In the other, that of a man who had swallowed about 7 grms. (¼ oz.) of oxalic acid, his voice, naturally deep, became in nine hours low and feeble, and continued so for more than a month, during the whole of which time he suffered in addition from numbness and tingling of the legs. As a case of extreme rarity may be mentioned that of a young woman,[*] who took 12 grms. (185 grains) of the acid oxalate of potash, and on the third day died; before death exhibiting delirium so active and intense that it was described as "madness."

Physiological Action.—Putting on one side the *local* effects of oxalic acid, and regarding only its true toxic effects, there is some difference of opinion as to its action. L. Hermann considers it one of the heart poisons, having seen the frog's heart arrested by subcutaneous doses of sodic oxalate, an observation which is borne out by the experiments of Cyon,[†] and not negatived by those of Kobert and Küssner. The poison is believed to act on the extracardial ganglia. Onsum[‡] held at one time a peculiar theory of the action of oxalic acid, believing that it precipitated as oxalate of lime in the lung capillaries, causing embolic obstruction; but this view is not now accepted—there are too many obvious objections to it. Kobert and Küssner do not consider oxalic acid a heart poison, but believe that its action is directed to the central nervous system, as attested by sinking of the blood-pressure, the arhythm and retardation of the pulse, the slow breathing and the paralytic symptoms.

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[*] *Journ. de Chim. Méd.*, 1839, p. 564.

[†] *Virch. Archiv*, Bd. xx., S. 233.

[‡] Almen afterwards supported Onsum's view; he made a number of microscopical observations, and appears to have been the first who identified oxalate of lime in the kidneys (Upsala, *Läkarel förennings, Ferhan*, Bd. ii. iv., S. 265.)

Pathological Changes.—Kobert and Küssner observed that when oxalate of soda was subcutaneously injected into animals, there was often abscess and even gangrene, at the seat of the injection. If the poison were injected into the peritoneal cavity, death was so rapid as to leave little time for any coarse lesions to manifest themselves. They were not able to observe a cherry-red colour of the blood, nor did they find oxalate of lime crystals in the lung capillaries; there were often embolic processes in the lung, but nothing typical. They came, therefore, to the conclusion that the state of the kidneys and the urine was the only typical sign. The kidneys were dark, full of blood, but did not show any microscopic hæmorrhages. Twelve hours after taking the poison there is observed in the cortical substance, a fine striping corresponding to the canaliculi; in exquisite cases the whole boundary layer is coloured white. If the poisoning lasts a longer time, the kidneys become less blood-rich, and show the white striping very beautifully; this change persists several weeks. The cause of this strange appearance is at once revealed by a microscopical examination; it is due to a deposition of oxalate of lime; no crystals are met with in the glomerules. By not alone the microscope, but also by chemical means, it may be shown that the content of the kidney in oxalates is large.* The urine was always albuminous and contained a reducing substance, which vanished about the second day after the dose. Hyaline casts and deposits of oxalate in the urine never failed.†

Observations of the pathological effects of the oxalates on man have been confined to cases of death from the corrosive substances mentioned, and hence the intestinal tract has been profoundly affected.

In the museum of St. Thomas' Hospital is a good example of the effects produced. The case was that of a woman who had taken a large, unknown quantity of oxalic acid, and was brought to the hospital dead. The mucous membrane of the gullet is much corrugated and divided into numerous parallel grooves; these again by little trànsverse grooves, so that the intersection of the two systems makes a sort of raised pattern. It is noted that in the recent state, the mucous membrane could be removed in flakes; in the upper part it was whitish, in the lower slate-coloured. The stomach has a large perforation, but placing the specimen beside another in the same museum which illustrates the effect of the gastric juice, in causing an after-death solution of a portion of the stomach, I was unable to differentiate between the two. The mucous membrane had the same shreddy flocculent appearance, and is soft and pale. The pyloric end is said to have been of a blackish colour, and no lymph was exuded.

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* The important fact of the oxalate-content of the kidneys and urine, and the expulsion of casts, was first observed by Mitscherlich in 1854. He noticed in a rabbit, to which had been given 7·5 grms. of oxalic acid, and which had died in thirteen minutes, "*renes paulutum magis sanguine replete videbantur in urina multa corpora inveniebantur quæ tubulos Bellenianes explese videntur*" (*De acidi acetici, oxalici, tartarici, citrici, formici, et boracico, &c., Berlin*).

† Rabuteau has discovered by experiment that even the oxalates of iron and copper are decomposed and separated by the kidneys. *Gaz. Méd. de Paris,* 1874.

The pathological changes by the acid oxalate of potash are identical with these of oxalic acid, in both the gullet and stomach being nearly always more or less inflamed or corroded; the inflammation in a few cases has extended right through into the intestinal canal; there are venous hyperæmia, hæmorrhages, and swelling of the mucous membrane of the stomach. The hæmorrhages are often punctiform, but occasionally larger, arranged in rows on the summits of the rugæ; sometimes there is considerable bleeding. In the greater number of cases there is no actual erosion of the stomach, but the inner layer appears abnormally transparent. On examining the mucous membrane under the microscope, Lesser* has described it as covered with a layer which strongly reflects light, and is to be considered as caused by a fine precipitate of calcic oxalate. Lesser was unable to find in any case oxalic acid crystals, or those of the acid oxalate of potash. There are many cases of perforation on record, but it is questionable whether they are not all to be regarded as *post-mortem* effects, and not life-changes; at all events there it little clinical evidence to support the view that these perforations occur during life. In the case (mentioned *ante*), in which death took place by coma, the brain was hyperæmic. The kidneys, as in the case of animals, show the white zone, and are congested, and can be proved by microscopical and chemical means to be rich in oxalates.

Separation of Oxalic Acid from Organic Substances, the Tissues of the Body, &c.—From what has been stated, no investigation as to the cause of poison, when oxalic acid is suspected, can be considered complete, unless the analyst has an opportunity of examining both the urine and the kidneys; for although, in most cases—when the acid itself, or the acid potassic salt has been taken—there may be ample evidence, both chemical and pathological, it is entirely different if a case of poisoning with the neutral sodic salt should occur. In this event, there may be no congested appearance of any portion of the intestinal canal, and the evidence must mainly rest on the urine and kidneys.

Oxalic acid being so widely distributed in the vegetable kingdom, the expert must expect, in any criminal case, to be cross-examined by ingenious counsel, as to whether or not it was possible that the acid could have entered the body in a rhubarb-pie, or accidentally through sorrel mixed with greens, &c. To meet these and similar questions it is important to identify, if possible, any green matters found in the stomach. In any case it must be remembered, that although rhubarb has been eaten for centuries, and every schoolboy has occasionally chewed small portions of sorrel, no poisoning has resulted from these practices. When oxalic acid has been taken into the stomach, it will invariably be found partly in combination with lime, soda, ammonia, &c., and partly free; or if such antidotes as chalk have been administered, it may be wholly combined. Vomiting is nearly always present, and valuable evidence of oxalic acid may be obtained from stains on sheets, carpets, &c. In a recent case of probably suicidal poisoning, the writer found no oxalic acid in the contents of the stomach, but some was detected in the copious vomit which had stained the bed-clothes. The urine also contained a great excess of oxalate of lime—a circumstance of little value taken by itself, but confirmatory with other evidence. If a liquid is strongly acid, oxalic acid may be separated by dialysis from organic matters, and the clear fluid thus obtained precipitated by sulphate of lime, the oxalate of lime being identified by its microscropic form and other characters.

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* Virchow' s *Archiv*, Bd. lxxxiii., S. 218, 1881.

The usual general method for the separation of oxalic acid from organic substances or mixtures is the following:—Extract with boiling water, filter (which in some cases must be difficult or even impossible), and then precipitate with acetate of lead. The lead precipitate may contain, besides oxalate of lead, phosphate, chloride, sulphate, and various organic substances and acids. This is to be decomposed by sulphuretted hydrogen, and on filtering off the sulphide of lead, oxalic acid is to be tested for in the filtrate. This process can only be adopted with advantage in a few cases, and is by no means to be recommended as generally applicable. The best general method, and one which insures the separation of oxalic acid, whether present as a free acid, as an alkaline, or a calcic oxalate, is perhaps the following:—The substance or fluid under examination is digested with hydrochloric acid until a fluid capable of filtration is obtained; the free acid is neutralised by ammonia in very slight excess, and permitted to deposit, the fluid is then carefully decanted, and the deposit thrown on a filter. The filtrate is added to the decanted fluid, and precipitated with a slight excess of acetate of lime—this precipitate, like the first, being collected on a filter. The first precipitate contains all the oxalic acid which was in combination with lime; the second, all that which was in the free condition. Both precipitates should be washed with acetic acid. The next step is to identify the precipitate which is supposed to be oxalate of lime. The precipitate is washed into a beaker, and dissolved with the aid of heat by adding, drop by drop, pure hydrochloric acid; it is then precipitated by ammonia, and allowed to subside completely, which may take some time. The supernatant fluid is decanted, and the precipitate washed by subsidence; it is lastly dried over the water-bath in a tared porcelain dish, and its weight taken. The substance is then identified by testing the dried powder as follows:—

(*a.*) It is whitish in colour, and on ignition in a platinum dish leaves a grey carbonate of lime. All other organic salts of lime—viz., citrate, tartrate, &c.—on ignition become coal-black.

(*b.*) A portion suspended in water, to which is added some sulphuric acid, destroys the colour of permanganate of potash—the reaction being similar to that on p. 481—a reaction by which, as is well known, oxalic acid or an oxalate may be conveniently titrated. This reaction is so peculiar to oxalic acid, that there is no substance with which it can be confounded. It is true that uric acid in an acid solution equally decolorises permanganate, but it does so in a different way; the reaction between oxalic acid and permanganate being first slow, and afterwards rapid, while the reaction with uric acid is just the reverse—at first quick, and towards the end of the process extremely slow.

(*c.*) A portion placed in a test-tube, and warmed with concentrated sulphuric acid, develops on warming carbon oxide and carbon dioxide; the presence of the latter is easily shown by adapting a cork and bent tube to the test-tube, and leading the evolved gases through baryta water.

Oxalate of Lime in the Urine.—This well-known urinary sediment occurs chiefly as octahedra, but hour-glass, contracted or dumb-bell-like bodies, compound octahedra, and small, flattened, bright discs, not unlike blood discs, are frequently seen. It may be usually identified under the field of the microscope by its insolubility in acetic acid, whilst the ammonio mag. phosphate, as well as the carbonate of lime, are both soluble in that acid. From urates it is distinguished by its insolubility in warm water. A chemical method of separation is as follows:—The deposit is freed by subsidence as much as possible from urine, washed with hot water, and then dissolved in hydrochloric acid and filtered; to the filtrate ammonia is added in excess. The precipitate may contain phosphates of iron, magnesia, lime, and oxalate of lime. On treatment of the precipitate by acetic acid, the phosphates of the alkaline earths (if present) dissolve, the insoluble portion will be either phosphate of iron, or oxalate of lime, or both. On igniting the residue in a platinum dish, any oxlate will be changed to carbonate, and the carbonate of lime may be titrated with d. n. HCl acid and cochineal solution, and from the data thus obtained the oxalate estimated. The iron can be tested qualitatively in the acid solution by ferrocyanide of potash, or it can be determined by the ordinary methods. If the qualitative detection of oxalate of lime in the deposit is alone required, it is quite sufficient evidence should the portion insoluble in acetic acid, on ignition in a platinum dish, give a residue effervescing on the addition of an acid.

Estimation of Oxalic Acid.—Oxalic acid is estimated in the free state by direct weighing, or by titration either with alkali or by potassic permanganate, the latter being standardised by oxalic acid. If (as is commonly the case) oxalic acid is precipitated as oxalate of lime, the oxalate may be—

(*a.*) Dried at 100° and weighed directly, having the properties already described.

(*b.*) Titrated with dilute sulphuric acid and permanganate.

(*c.*) Ignited, and the resulting carbonate of lime weighed; or dissolved in standard acid and titrated back—one part of calcic carbonate corresponds to 1·26 part of crystallised oxalic acid, or ·88 part of C_2O_4; similarly, 1 cc. of standard acid equals ·05 of calcic carbonate (or ·063 of crystallised oxalic acid).

(*d.*) The oxalate may be dissolved in the smallest possible amount of hydrochloric acid, and boiled with ammonio chloride of gold, avoiding exposure to light; every part of gold precipitated corresponds to ·961 parts of crystallised oxalic acid.

(*e.*) The oxalate may be placed in Geissler's carbonic acid apparatus, with peroxide of manganese and diluted sulphuric acid. The weight of the gas which at the end of the operation has escaped, will have a definite relation to that of the oxalate, and if multiplied by 1·4318 will give the amount of crystallised oxalic acid.

CERTAIN OXALIC BASES—OXALMETHYLINE—OXALPROPYLINE.

Hugh Schulz[*] and Mayer have recently contributed the results of some important researches bearing upon a more exact knowledge of the effects of the oxalic group of poisons, and upon the relation between chemical constitution and physiological effects. They experimented upon *oxalmethyline*, *chloroxalmethyline* and *oxalpropyline*.

Chloroxalmethyline ($C_6H_9ClN_2$) is a liquid, boiling at 205°, with a weakly narcotic smell. A solution of the hydrochlorate of the base was employed. Subcutaneous injections of ·05 grm. into frogs caused narcosis, and both this and the ethylic compound deranged the heart's action, decreasing the number of beats. Thus ·05 grm. decreased the number of the beats of the heart of a frog in the course of one and three-quarter hours, as follows: 72, 60, 56, 50, 44, 40, 35, 0.

Oxalmethyline produces somewhat similar symptoms, but the nervous system is more affected than in that which contains chlorine.

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[*] *Beitrag zur Kenntniss der Wirkung der Oxalbasen auf den Thierkörper. Arch. f. Exper. Path. u. Pharm.*, 1882.

Oxalpropyline also causes narcosis, and afterwards paralysis of the hinder extremities and slowing of the heart.

The difference between the chlorine-free and the chlorine-containing oxalic bases are summarised as follows:—

	Chlorine-Holding Bases.	Chlorine-Free Bases.
FROGS.	Notable narcosis; no heightened reflex action, muscular cramps, nor spontaneous convulsions.	Narcosis occurs late, and is little pronounced; a notable increase of reflex excitability; more and more muscular paralysis; between times, muscular cramps.
CATS.	Notable narcosis and salivation; no mydriasis; convulsions and paralysis; no change in the respirations.	Great excitement; general shivering, rising to pure clonic convulsions; paralysis of the hind legs; notable mydriasis, jerking, and superficial respiration; weak narcosis.
DOGS.	Notable narcosis; occasional vomiting; the rest as in cats.	Narcosis evident; the rest as in cats.

PART VIII. –INORGANIC POISONS.

I.—PRECIPITATED FROM A HYDROCHLORIC ACID SOLUTION BY HYDRIC SULPHIDE—PRECIPITATE YELLOW OR ORANGE.

ARSENIC—ANTIMONY—CADMIUM.

1. ARSENIC.

Metallic Arsenic, at. wt. 75, specific gravity of solid 5·62 to 5·96, sublimes without fusion in small quantities at 110° (230° F.) *Guy.* It occurs in commerce in whitish-grey, somewhat brittle, crystalline masses, and is obtained by subjecting arsenical pyrites to sublimation in earthen retorts, the arsenic being deposited in suitable receivers on sheet iron. In the course of analysis, however, it is usually seen as a film on copper, a stain on porcelain, or a metallic ring in the interior of glass tubes : the distinctive marks of these stains are described, p. 526. Metallic arsenic is probably not poisonous, but may be changed by the animal fluids into soluble compounds, and then exert toxic effects—volatilised metallic arsenic is transformed into arsenious acid, and is therefore intensely poisonous.

Arsenious Anhydride—Arsenious Acid—White Arsenic—Arsenic, As_2O_3=198 ; specific gravity of vapour, 13·85 ; specific gravity of opaque variety, 3·699 ; specific gravity of transparent variety, 3·7385. Composition in 100 parts, As 75·75, O 24·25 ; therefore one part of metallic arsenic equals 1·32 of As_2O_3.

In analysis it is obtained in brilliant octahedral crystals as a sublimate in discs or glass, or within tubes, the result of heating a film of metallic arsenic with access of air. It is obtained in commerce on a very large scale from the roasting of arsenical pyrites. As thus derived, it is usually in the form of a white cake, the arsenious acid existing in two forms—an amorphous and a crystalline—the cake being generally opaque externally, whilst in the centre it is transparent. According to Kruger, this change from the crystalline to the amorphous condition is dependent upon the absorption of moisture, no alteration taking place in dry air. Both varieties of arsenious anhydride are acid to test paper.

The solubility of arsenious acid is often a question involving chemical legal matters of great moment. Unfortunately, however, no precisely definite statement can be made on this point, the reason being that the two varieties of arsenic occur in very different proportions in different samples. Both the amorphous and crystalline varieties having very unequal solubilities, every experimenter in succession has given a different series of figures, the only agreement amid the general discrepancy being that arsenic is very sparingly soluble in water.

The statement of Taylor may, however, be accepted as very near the truth—viz., that an ounce of cold water dissolves from half a grain to a grain. According to M. L. A. Buchner,* one part of crystalline arsenious acid dissolves after twenty-four hours digestion in 355 parts of water at 15°; and the amorphous, under the same condition, in 108 of water. A boiling solution of the crystalline acid, left to stand for twenty-four hours, retains one part of acid in 46 of water; a similar solution of the amorphous retains one of arsenic in 30 parts of water—*i.e.*, 100 parts of water dissolve from 2·01 to 3·3 parts of As_2O_3.

Boiling water poured on the powdered substance retains in cooling a grain and a quarter to the ounce; in other words, 100 parts of water retain ·10. Lastly, arsenious acid boiled in water for an hour is dissolved in the proportion of 12 grains to the ounce—*i.e.*, 100 parts of water retain 2·5.

Arseniuretted Hydrogen Arsine, H_3As.—Mol. weight, 78; vol. weight, 39; specific gravity, 2·702; weight of a litre, 3·4944; percentage composition, 95·69 As, 4·31 H; volumetric composition, 2 vol. H_3As=half vol. $Ac+3$ vol. H. A colourless inflammable gas, of a fœtid alliaceous odour, coercible into a limpid colourless liquid at a temperature of from $-30°$ to $-40°$. The products of the combustion of arseniuretted hydrogen are water and arsenious acid; thus, $2H_3As+6O=3H_2O+AS_2O_3$. If supplied with air in insufficient quantity, if the flame itself be cooled by (for example) a cold porcelain plate, or if the gas pass through a tube any portion of which is heated to redness, the gas is decomposed and the metal separated. Such a decomposition may be compared to the deposit of carbon from ordinary flames, when made to play upon a cooled surface. The gas burns with a blue-white flame, which is very characteristic, and was first observed by Wackenroder. It cannot, however, be properly seen by using the ordinary apparatus of Marsh, for the flame is always coloured from the glass; but if the gas is made to stream through a platinum jet, and then ignited, the characters mentioned are very noteworthy.

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* *Bull. de la Société Chem. de Paris*, t. xx. 10, 1873.

Oxygen or air, and arseniuretted hydrogen, make an explosive mixture. Chlorine decomposes the gas with great energy, combining with the hydrogen, and setting free arsenic as a brown cloud ; any excess of chlorine combines with the arsenic as a chloride. Sulphur, submitted to arseniuretted hydrogen, forms sulphuretted hydrogen, whilst first arsenic and then sulphide of arsenic separate. Phosphorus acts in a similar way. Arseniuretted and sulphuretted hydrogen may be evolved at ordinary temperatures without decomposition ; at the boiling point of mercury (350°) they are decomposed, sulphide of arsenic and hydrogen being formed ; thus, $3H_2S+2AsH_3=As_2S_3+6H_2$, a reaction which is of some importance from a practical point of view. Many metals have also the property of decomposing the gas at high temperatures, and setting hydrogen free. Metallic oxides, again, in like manner, combine with arsenic, and set water free, *e.g.*, $3CuO+2H_3As=Cu_3As_2+3H_2O$.

Arseniuretted hydrogen acts on solutions of the noble metals like phosphuretted hydrogen, precipitating the metal and setting free arsenious acid ; for example, nitrate of silver is decomposed thus—

$$12AgNO_3+2H_3As+3H_2O=As_2O_3+12HNO_3+12Ag.$$

This reaction admits of valuable practical application to the estimation of arsenic ; for the precipitated silver is perfectly arsenic free ; the excess of nitrate of silver is easily got rid of by a chloride of sodium solution, and the absorption and decomposition of the gas are complete.

In cases of poisoning by arseniuretted hydrogen, the blood, when examined by the spectroscope (a process the analyst should never omit where it is possible), is of a peculiar inky colour, and the bands between D and C are melted together, and have almost vanished. Such blood, exposed to oxygen, remains unaltered.

Arseniuretted Hydrogen in the Arts, &c.—In the bronzing of brass, in the desilverising of lead by zinc, and subsequent treatment of the silver zinc with hydrochloric acid, in the tinning of sheet iron, and similar processes, either from the use of acids containing arsenic as an impurity, or from the application of arsenic itself, arseniuretted hydrogen is evolved. Of late years, moreover, this gas has been recognised as a source of disease, by being emanated from wall papers which had been strongly impregnated with arsenic, the gas resulting from the contact of arsenious acid with organic matter.*

The researches of Fleck, ridiculed by L. Krahmer,† are confirmed by Sonnenschein,‡ who, by the aid of an aspirator, drew the air of a room first through water, and then through a red-hot glass tube, and obtained a distinct arsenical ring. They are further attested by Hamberg,[*] who, in a similar manner, caused the air of a room, the wall-paper of which was arsenical, to pass through a solution of nitrate of silver, and obtained in the solution arsenious acid, together with some sulphide of silver;[†] very few solid particles being detected.

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* Fleck, *Zeitschr. für Biologie*, Bd. viii., p. 445.

† *Handbuch der Staats-Arzneikunde*, ii., 455.

‡ Sonnenschein, *Handbuch der Gerichtlichen Chemie.*

Effects on Animals and Man of Breathing Arsine.—The most general effect on mammals is to produce jaundice, bloody urine, and bile. In the course of numerous experiments on dogs, Stadelmann[‡] found that by making them breathe a dose of arseniuretted hydrogen, which would not be immediately fatal, icterus was always produced under these circumstances, and could be always detected by the appearance of the tissues. The bile is remarkably thickened, and the theory is, that in such cases the jaundice is purely mechanical, the gall-duct being occluded by the inspissated bile. Rabbits experimented upon similarly showed increased biliary secretion, but no jaundice; while it was proved that cats are not so sensitive to arsine as either rabbits or dogs. There are not wanting instances of arsine having been breathed by man—the discoverer of the gas, Gehlen, was in fact the first victim on record. In order to discover a flaw in his apparatus he smelt strongly at the joints, and died in eight days from the effects of the inhalation.

Nine persons, workmen in a factory, were poisoned by arseniuretted hydrogen being evolved during the treatment by hydrochloric acid of silver-lead containing arsenic. Three of the nine died, their spmptoms were briefly as follows:—

(1.) H. K., 22 years old; his duty was to pour hydrochloric acid on the metal. Towards mid-day, after this operation, he complained of nausea, giddiness, and *malaise*. In the afternoon he felt an uncommon weight of the limbs, and an oppression in breathing. His fellow-workmen thought that he looked yellow. On going home he lay down and passed into a narcotic sleep. Next morning he went to his work as usual, but was not capable of doing anything; he passed bloody urine several times throughout the day, and fell into a deep sleep, from which he could scarcely be roused. On the third day after the accident, a physician called in found him in a deep sleep, with well-developed jaundice, the temperature moderately high, pulse 100. On the fifth day the jaundice diminished, but it was several months before he could resume his work.

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[*] *Pharm. Journ. Trans.*, [3], pp. 81-83.

[†] The unpleasant odour often possessed by Schweinfurt green papers appears to be due to the decomposition of the acetic acid by moisture and mould, with the formation as a principal product of propionic acid.

[‡] *Die Arsenwasserstoff-Vergiftung, Archiv. f. Exper. Path. u. Pharm. Leipzig*, 1882.

(2.) J. T., aged 19, suffered from similar symptoms after five and a half hours' exposure to the gas. He went home, vomited, was jaundiced, and suffered from bloody urine; in six days became convalescent, but could not go to work for many months.

(3.) C. E. was very little exposed, but was unwell for a few days.

(4.) L. M., 37 years old, was exposed two days to the gas; he vomited, had bloody urine, passed into a narcotic sleep, and died in three days from the date of the first exposure.

(5.) J. S., aged 40, was exposed for two days to the gas; the symptoms were similar to No. 4, there was suppression of urine, the catheter drawing blood only, and death in eight days.

(6.) M. E., 36 years old; death in three days with similar symptoms.

(7), (8), and (9) suffered like Nos. 1 and 2, and recovered after several months.

The chief *post-mortem* appearance was a dirty-green colour of the mucous membrane of the intestines, and congestion of the kidneys. Arsenic was detected in all parts of the body.*

Two cases are detailed by Dr. Valette in Tardieu's "Etude."† A mistake occurred in a laboratory, by which a solution of arsenic (instead of sulphuric acid) was poured on zinc to develop hydrogen. Of the two sufferers, the one recovered after an illness of about a week or ten days, the other died at the end of twenty-eight days. The main symptoms were yellowness of skin, vomiting, bloody urine, great depression, slight diarrhœa, headache, and in the fatal case a morbiliform eruption. In a case recorded in the *British Medical Journal*, November 4, 1876, there were none of the usual symptoms of gastric irritation, but loss of memory of recent acts, drowsiness, and giddiness.

The Sulphides of Arsenic.—Of the sulphides of arsenic, two only, realgar and orpiment, are of any practical importance. *Realgar*, As_2S_2= 214; specific gravity, 3·356; composition in 100 parts, As 70·01, S 29·91; average composition of commercial product, As 75, S 25. Realgar is found native in ruby-red crystals, and is also prepared artificially by heating together 9 parts of arsenic and 4 of sulphur, or 198 parts of arsenious anhydride with 112 parts of sulphur, $2As_2O_3+7S=2As_2S_2+3SO_2$. It is insoluble in water and in hydrochloric acid, but is readily dissolved by potassic disulphide, by nitric acid, and by aqua regia It is decomposed by caustic potash, leaving undissolved a brown sediment ($As_{12}S$), which contains 96·5 per cent. of arsenic.

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* Trost. *Vergiftung durch Arsenwasserstoff bei der technischen Gewinnung des Silbers*, *Vierteljahrsschrift f. Gericht. Med.*, xviii., Bd. 2, Heft, S. 6, 1873.

† Ambroise Tardieu, *Etude Medico-légale sur l'Empoisonnement*, Obs. xxv., p. 449.

Orpiment, or Arsenic Trisulphide.—$As_2S_3=246$; specific gravity, 3·48; composition in 100 parts, As 60·98, S 39·02; found native in crystals, presents itself in the laboratory usually as a brilliant yellow amorphous powder, on passing sulphuretted hydrogen through as acid solution of arsenious acid or an arsenite. It is very insoluble in water (about one in a million, *Fresenius*), scarcely soluble in boiling concentrated hydrochloric acid, and insoluble generally in dilute acids. Red fuming nitric acid dissolves it, converting it into arsenic and sulphuric acid; ammonia and other alkaline sulphides, the alkalies themselves, alkaline carbonates, bisulphide of potash, and aqua regia, all dissolve it readily. In the arts it is used as King's yellow (see p. 477). Tanners also formerly employed a mixture of 90 parts of orpiment and 10 of quicklime, under the name of *Rusma*, as a depilatory; but the alkaline sulphides from gas works are replacing this to a great extent.

Haloid Arsenical Compounds.—The Chloride of Arsenic, $AsCl_3=181{\cdot}5$; specific gravity liquid, 0° 2·205; boiling point, 134° (273·2° F.), is a heavy, colourless, oily liquid, which has been used as an escharotic in cancerous affections (principally by quacks). In one process of detecting and estimating arsenic, the properties of this substance are ultilised (see p. 515). It is immediately decomposed by water into arsenious and hydrochloric acids.

The Iodide of Arsenic (AsI_3) is used occasionally in skin diseases, but is of little interest to the analyst; it is commonly seen in the form of brick-red brilliant flakes.

Arsenic in the Arts.—The metal is used in various alloys; for example, speculum metal is made of tin, copper, and a little arsenic; white copper is an alloy of copper and arsenic; shot is composed of 1000 parts of lead mixed with 3 of arsenic; the common Britannia metal used for tea-pots, spoons, &c., often contains arsenic; and brass is bronzed with a thin film of arsenic. It was formerly much employed in the manufacture of glass, but is being gradually superseded. It is also now used to some extent in the reduction of indigo blue, and in that of nitrobenzole in the manufacture of aniline.

In cases of suspected poisoning, therefore, and in the finding of arsenic in the stomach, or elsewhere, it may be set up as a defence that the arsenic was derived from shot used in the cleansing of bottles, from the bottles themselves, or from metal vessels, such as tea-pots, &c.

The arsenic in all these alloys being extremely insoluble, any solution to a poisonous extent is in the highest degree improbable. It may, however, be necessary to treat the vessels with the fluid or fluids which have been supposed to exert this prejudicial action, and test them for arsenic.

The treatment should, of course, be of a severe and exhaustive character, and the fluids should be allowed to stand cold in the vessels for twenty-four hours; then the effect of a gentle heat should be studied, and, lastly, that of boiling temperatures. The analysis of the alloy itself, or of the glass, it would seldom be of value to undertake, for the crushed and finely-divided substance is in a condition very different from that of the article when entire, and inferences drawn from such analytical data would be fallacious. It does not matter one iota to us that the vessels out of which we drink are made of metallic arsenic, provided that under all possible domestic conditions the arsenic is insoluble.

Arsenious anhydride is also used for the preservation of wood, and is thrown occasionally into the holds of vessels in large quantities to prevent vegetable decomposition. In India, again, a solution of arsenic is applied to the walls as a wash, in order to prevent the attacks of insects.

Pharmaceutical, Non-officinal, and other Preparations of Arsenic.—(1.) *Pharmaceutical Preparations.*—The *liquor arsenicalis* (Fowler's solution), or solution of arsenic of the pharmacopœia, is composed of—

Carbonate of Potash, ...	80 grains (5·18 grms.)
Arsenious Acid, ...	80 " (5·18 ")
Compound Tincture of Lavender, .	5 drachms (17·72 cc.)

dissolved in 1 pint (567·9 cc.) of water; every ounce, therefore, contains 4 grains of arsenious acid (or 100 cc.$=·9As_2O_3$).

The *hydrochloric solution of arsenic* is simply arsenious acid dissolved in hydrochloric acid; its strength should be exactly the same as that of Fowler's solution.

A solution of *arseniate of soda*[*] contains the *anhydrous* salt in the proportion of 4 grains to the ounce (·9 in 100 cc.) of water.

Donovan's Solution of Arsenic.—This is not officinal, but is used to some extent in skin diseases; it appears to be a solution of the iodides of mercury and arsenic; 100 cc. contain about ·152 grm. of metallic arsenic, or each fluid drachm contains ·086 grains.

Arsenate of Iron, $Fe_3As_2O_8$, is an amorphous green powder, used to some extent in medicine. It should contain 33·6 per cent. of metallic arsenic.

(2.) *Veterinary Arsenical Medicine.*—Common veterinary preparations containing arsenic are :—A ball for worms, containing in parts—

Calomel, ...	1·3 per cent.
Arsenious Acid, ...	1·3 "

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[*] The formula for arseniate of soda is $Na_2HAsO_4 7H_2O$, but it sometimes contains more water.

Tin Filings,	77·9 per cent.
Venice Turpentine *	19·5 "

A common tonic ball :—†

Arsenious Acid,	5 to 10 grains	(·324 to ·648 grm.)
Aniseed,	½ oz.	(14·1744 grms.)
Opium,	30 grains	(1·94 "
Treacle,	q. s.	

An arsenical ball, often given by grooms to horses for the purpose of improving their coats, contains in 100 parts—

Arsenious Acid,	2·5 per cent.
Pimento,	19·2 "
Extract of Gentian,	78·3 "

Another ball in use is composed of arsenic and verdigris (acetate of copper), of each 8 grains (·518 grm.); cupric sulphate, 20 grains (1·3 grm.); q. s. of linseed meal and treacle.

(3.) *Rat and Fly Poisons, &c.*—An arsenical paste sold for rats has the following composition :—

Arsenious Acid,	5·0 per cent.
Lampblack,	·6 "
Wheat Flour,	46·3 "
Suet,	46·3 "
Oil of Aniseed, a small quantity.	

Another rat poison is composed as follows :—

White Arsenic,	46·8 per cent.
Carbonate of Baryta,	46.8 "
Rose-pink,‡	5·8 "
Oil of Aniseed,	·2 "
Oil of Rhodium,	·2 "

Various arsenical preparations are used to kill flies; the active principle of the brown "*papier moure*" is arsenious acid. A dark grey powder, which used to be sold under the name of fly-powder, consisted of metallic arsenic that had been exposed some time to the air.

Fly-water is a strong solution of arsenious acid of uncertain strength, sweetened with sugar, treacle, or honey. Another fly-poison consists of a mixture of arsenious acid, tersulphide of arsenic, treacle, and honey.

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* The Venice turpentine is rarely found in ordinary commerce, what is sold under that name consisting of black resin and oil of turpentine.

† A similar preparation in common use has the addition of sulphate of zinc.

‡ Alum and carbonate of lead coloured with Brazil and peach woods.

(4.) *Quack Nostrums.*—The analyst may meet with several quack preparations for external use in cancer. A celebrated arsenical paste for this purpose is composed of—

Arsenious Acid, ...	8 per cent.
Cinnabar, ...	70 "
Dragon's Blood, ...	22 "

A pill, used by unprofessional persons as a preventive of hydrophobia (!) is composed of $\frac{1}{16}$ to $\frac{1}{12}$ (4 to 5·4 mgrms.) of a grain of arsenic and a grain of common pepper. A similar pill is much used in the East Indies.

The tasteless "*ague-drops*" used in the fen countries are simply a solution of arsenite of potash.

Davidson's Cancer Remedy consists, according to Dr. Paris, of equal parts of arsenious acid and powdered hemlock.

In India, arsenic given as a medicine by native practitioners, or administered as a poison, may be found coloured and impure, from having been mixed either with cow's urine, or with the juice of leaves, &c.*

Arsenious acid is used by dentists to destroy the nervous pulp of decayed and painful teeth, about the twenty-fifth of a grain (2·5 mgrms.) being placed in the cavity. There is no record of any accident having resulted from this practice hitherto; but since the dentist seldom weighs the arsenic, it is not altogether free from danger.

(5.) *Pigments, &c.*—*King's yellow* should be As_2S_3, the trisulphide of arsenic or orpiment. It is frequently adulterated with 80 to 90 per cent. of arsenious acid, and in such a case, of course, more poisonous. King's yellow, if pure, yields to water nothing which gives any arsenical reaction.

A blue pigment, termed *mineral blue*, consists of about equal parts of arsenite of copper and potash, and should contain 38·7 per cent of metallic arsenic (=to 51·084 As_2O_3H), and 15·6 of copper.

Schweinfurt green (Syn. *Emerald-green*), $(CuAs_2O_4)_3Cu(C_2H_3O_2)_2$ is a cupric arsenite and acetate, and should contain 25 per cent. of copper, and 58·4 per cent. of arsenious acid. In analysis, the copper in this compound is readily separated from the arsenic by first oxidising with nitric acid, and then adding to the nitric acid solution ammonia, until the blue colour remains undissolved. At this point ammonium oxalate is added in excess, the solution is first acidified by hydrochloric or nitric acid, and, on standing, the copper separates completely (or almost so) as oxalate, the arsenic remaining in solution.

Scheele's green ($CuHAsO_3$) is a hydrocupric arsenite, and contains 52·8 per cent. of arsenious anhydride, and 33·8 per cent of copper.

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* Chever, *Med Jurisprudence for India*, p. 116.

(6.) *External Application of Arsenic for Sheep, &c.*—Many of these are simply solutions of arsenic, the solution being made by the farmer. Most of the yellow sheep-dipping compounds of commerce are made up either of impure carbonate of potash, or of soda ash, arsenic, soft soap, and sulphur. The French *bain de tersier* is composed of—

Arsenious Acid,	1·00 kgrms.
Ferrous Sulphate,	10·00 ,,
Peroxide of Iron,	0·40 ,,
Gentian Powder,	0·20 ,,

This is to be added to 100 kgrms. of water. Another common application consists of alum and arsenic (10 or 12 to 1), dissolved in two or three hundred parts of water.

(7.) *Arsenical Soaps, &c.*—Arsenic is used in preserving the skins of animals. One of the compounds for this purpose, known under the name of *Bécoeur's arsenical soap,* has the following composition :—

Camphor,	3·4 per cent.
Arsenic,	20·2 "
Carbonate of Potash,	56·2 "
Lime,*	20·2 "

(8.) *Arsenical compounds* used in pyrotechny :—

		Parts.
Blue fires — (1.)	Realgar,	2
	Charcoal,	3
	Potassic Chlorate,	5
	Sulphur,	13
	Nitrate of Baryta,	77
(2.)	Sulphur,	40·9
	Nitre,	36·8
	Sulphide of Antimony,	12·3
	,, Arsenic,	5
	Charcoal.	5
Green fires —	Metallic Arsenic,	2
	Charcoal,	3
	Chlorate of Potash.	5
	Sulphur,	13
	Nitrate of Baryta,	7
Light green fire—	Charcoal,	1·75
	Sulphide of Arsenic,	1·75
	Sulphur,	10·50
	Chloride of Potash,	23·25

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* The dust from the preserved skins of animals has caused, at least, one case of poisoning. *Ann. d'Hyg. Pub. et de Méd. Lég.*, 2 sér., 1870, t. xxxiii., p. 314.

		Parts.
	Nitrate of Baryta,	62·50
White fire—(1.)	Arsenious Acid,	·76
	Charcoal,	1·63
	Sulphide of Antimony,	12·27
	Nitrate of Potash,	36·59
	Sulphur,	48·75
(2.)	Realgar,	6·1
	Sulphur,	21·2
	Nitrate of Potash,	72·7

Statistics of Poisoning by Arsenic.—In England, during the five years ending 1880, in 1581 cases of poisoning from all causes, 37 males and 30 females are registered as having died from arsenical poisoning. Of these deaths 28 (41·7 per cent.) were suicidal; 2 children were murdered by arsenic; the remaining 37 (55·2 per cent.) were due to accident or negligence. With regard to the ages, 3 only were under 5 years of age; 32, or about one-half, were between 20 and 45; 16 between 45 and 75; and 3 above 75 years of age. Husemann collected 183 cases of arsenical poisoning; of these 89 (48·5 per cent.) were either suicidal or murderous, the data relative to 6 were wanting, the remainder were accidental; of the 183, 81 (44 per cent.) proved fatal. If the same proportion holds good in England, then the 67 deaths from arsenical poisoning would be equivalent to 175 cases.

Law Relative to the Sale of Arsenic.—By the 14th of Vict. c. 12, every person selling arsenic is bound to keep a written record of every particular relative to each transaction, such as the name, abode, and calling of the purchaser, the purpose for which the poison is required, and the quantity sold, &c. These particulars are to be signed also by the purchaser. No person (sec. 2) is allowed to sell arsenic to any one unknown to the seller, unless in the presence of a witness, whom the seller is acquainted with. The arsenic sold (sec. 3), is to be mixed with soot or indigo in the proportion of half an ounce of indigo to a pound of arsenic. It, therefore, follows that the coloured substance should not contain more than 70 per cent. of arsenious acid. The Act applies to all the colourless preparations of arsenic: but it is not to affect chemists in making up prescriptions for medical men, or in supplying medical men; nor is it to affect the wholesale dealers in supplying arsenic to retail shops, &c. The penalty for conviction is £20, or less. Commercial arsenic is often much adulterated, especially with gypsum, chalk, &c. These are most readily detected by subliming the arsenic. The sublimed arsenic itself may not be entirely pure, sometimes containing arsenical sulphides and antimonious oxide.

Dose.—The smallest dose of arsenic known to have proved fatal to a human being is ·16 grm. (2½ grains). Farriers and grooms are in the habit of giving as much as 1·3 grm. (20 grains) a day to a horse, so that the poisonous dose for this animal must be very large.

The maximum dose for the horned cattle appears to be from ·32 to ·38 grm. (5 to 6 grains); that for a dog 16 mgrms. (¼ grain), and even this may, in the smaller kinds, cause illness.

The following may be considered as *dangerous doses* of arsenic :—·13 grm. (2 grains) for an adult; 1·9 grm. (30 grains) for a horse; ·64 grm. (10 grains) for a cow; and 32 to 64 mgrms. (½ to 1 grain) for a dog.

Effects of Arsenious Acid on Plants.—If the root or stem of a plant is immersed in a solution of arsenious acid, the hue of the leaves soon alters in appearance, the green colour becomes of a whitish or brownish hue, and the plant withers; the effect being very similar to that produced by hot water. The toxic action may be traced from below upwards, and analysis will detect minute quantities of arsenic in all portions of the plant.

It has, however, been shown by Gorup-Besanez,* that if arsenious acid be mixed with earth, and plants grown in such earth, they only take up infinitesimal quantities of arsenic. Hence, in cases of cattle poisoning, any defence based upon the alleged presence of arsenic in the pasture will be more ingenious than just.

The influence of arsenical fumes as evolved from manufactories upon shrubs and trees is in general insignificant. Pines and firs, five to six years old, have been known to suffer from a disease in which there is a shedding of the leaves, the more tender herbage being at the same time affected. Whatever dangers the practice of steeping corn intended for seed in a solution of arsenious acid as a preventive of "smut," may possess, it does not appear to influence deleteriously the growth of the future plant.

Superphosphate of manure is frequently rich in arsenic. Dr. Edmund Davy asserts that plants to which such manure is applied take up arsenic in their tissues, and M. Andonard has made a similar statement. Tuson† has also undertaken some experiments, which confirm Andonard and Davy's researches. The bearing of this with relation to the detection of arsenic in the stomachs of the herbivora needs no comment.

Effects on Animal Life—Animalcules.—All infusoria and forms of animalcule-life hitherto observed, perish rapidly if a minute quantity of arsenious acid is dissolved in the water in which they exist.

Insects.—The common arsenical fly-papers afford numerous oppor-

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***Annal. d. Chemie u. Pharmacie*, Bd. cxxvii., H. 2, 243.

†Cooley's *Dictionary*, Art "Arsenic."

tunities for observing the action of arsenic on ordinary flies; within a few minutes (five to ten after taking the poison into their digestive organs) they fall, apparently from paralysis in the wings, and die. Spiders and all insects into which the poison has been introduced exhibit a similar sudden death. It is said that in the neighbourhood of arsenical manufactures there is much destruction among bees and other forms of insect life.

Annelids.—If arsenious acid is applied to the external surface of worms or leeches, the part which it touches perishes first, and life is extinguished successively in the others. If a wound is made first, and the arsenious acid then applied to it, the effects are only intensified and hastened. There is always noticed an augmentation of the excretions; the vermicular movements are at first made more lively, they then become languid, and death is very gradual.

Birds.—The symptoms with birds are somewhat different, and vary according to the form in which the poison is administered—viz., whether as in a vapour or solution. In several experiments made by Eulenberg on pigeons, the birds were secured under glass shades, and exposed to the vapour of metallic arsenic vaporised by heat. It is scarcely necessary to remark that in operating in this way, the poisoning was not by metallic arsenic vapour, but by that of arsenious acid. One of these experiments may be cited:— A pigeon was made to breathe an atmosphere charged with vapour from the volatilisation of metallic arsenic. The bird was immediately restless; in thirty minutes it vomited repeatedly, and the nasal apertures were noticed to be moist; after a little while, the bird, still breathing the arsenious atmosphere, was much distressed, shook its head repeatedly, and yawned; in fifty minutes the respiration was laboured, and in fifty-nine minutes there was much vomiting. On removing the bird, after it had been exposed an hour to the vapour (·16 grm. of metallic arsenic having been evaporated in all), it rapidly recovered.

Six days after, the pigeon was again exposed in the same way to the vapour, but this time ·56 grm. of metallic arsenic was volatilised. In fifteen minutes there was retching, followed by vomiting. On taking it out after an hour it remained very quiet, ate nothing, and often puffed itself out; the breathing was normal, movements free, but it had unusual thirst. On the second and third day the excretions were frequent and fluid; the cardiac pulsations were slowed, and the bird was disinclined to move. On the fourth day it continued in one place, puffing itself out; towards evening the respirations slowed, the beak gaping at every inspiration. On attempting flight, the wings fluttered and the bird fell on its head. After this it lay on its side, with slowed laboured respiration, the heart-beats scarcely to be felt, and death took place without convulsions, and very quietly. On examining the organs after death, the brain and spinal cord were very bloodless; there were ecchymoses in the lungs; but little else characteristic. The experiment quoted has a direct bearing upon the breathing of arsenical dust; as, for example, that which floats in the air of a room papered with an easily detached arsenical pigment. Other experiments on birds generally have shown that the symptoms produced by arsenious acid in solution, or in the solid form, in a dose insufficient to destroy life, are languor, loss of appetite, and the voidance of large quantities of liquid excreta like verdigris. With fatal doses, the bird remains quiet; there are fluid, sometimes bloody, excretions; spasmodic movements of the pharynx, anti-peristaltic contraction of the œsophagus, vomiting, general trembling of the body, thirst, erection of the feathers, and laboured respiration. The bird becomes very feeble, and the scene mostly closes with insensibility and convulsions.

Mammals, such as cats, dogs, &c., suffer from symptoms fairly identical with those observed in man; but the nervous symptoms (according to P. Hugo) do not predominate, while with rabbits and guinea-pigs, nervous symptoms are more marked and constant.* There are vomiting, purging, and often convulsions and paralysis before death. It has been noticed that the muscles after death are in a great state of contraction. The slow poisoning of a dog, according to Lolliot,† produced an erythematous eruption in the vicinity of the joints, ears, and other parts of the body; there were conjunctivitis, increased lachrymal secretion, and photophoba; the hair fell off.

Effects of Arsenious Acid on Man.—The symptoms produced by arsenious acid vary according to the form of the poison—whether solid, vaporous, or soluble—according to the condition of bodily health of the person taking it, and according to the manner in which it is introduced into the animal economy, while they are also in no small degree modified by individual peculiarities of organisation and by habit, as, for instance, in the arsenic-eaters.

Arsenic-Eaters.—In all European countries grooms and horse-dealers are acquainted with the fact that a little arsenic given daily in the corn improves the coat, increases, probably, the assimilation of the food, and renders the horse plump and fat. On the Continent grooms have been known to put a piece of arsenic, the size of a pea, in a little oatmeal, make it into a ball, tie it up in a linen rag, and attach it to the bit, the saliva dissolves, little by little, the poison, while both the gentle irritation and physiological action excite a certain amount of salivation, and the white foam at the mouth, and the champing of the horse, are thought vastly to improve the appearance. Shot, which contains a small quantity of arsenic, have been used for the same purpose, and from half a pound to a pound of small shot has been given to horses. When a horse has been for a long time dosed with arsenic, it seems necessary to continue the practice; if this is not done, the animal rapidly loses his condition. The explanation probably is that the arsenic stimulates the various cells and glands of the intestinal tract to a superaction, the natural termination of which is an enfeeblement of their secreting power—this especially in the absence of the stimulus. Turning from equine involuntary arsenic-eaters, we find the strange custom of arsenic eating voluntarily pursued by the races of lower Austria and Styria, especially by those dwelling on the mountains separating Styria from Hungary. In India also (and especially in the Punjaub) the same practice prevails, and here it is often taken as an aphrodisiac. The mountaineers imagine that it increases the respiratory power, nor is there wanting some evidence to show that this is actually the fact, and medicinal doses of arsenic have been in use for some time in cases of asthma and other diseases of the chest. The arsenic-eaters begin with a very small dose, which is continued for several weeks or months, until the system gets accustomed to it. The amount is then slightly augmented until relative large doses are taken with impunity. In one case* it appears that a countryman, in good health, and sixty years of age, took daily four grains of arsenious acid, a habit which he had inherited from his father, and which he in turn bequeathed to his son.

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* *Archiv f. Exper. Path. u. Pharmakol.* Leipzig, 1882.

† *Etude Physiol. d'Arsène.* Thèse, Paris, 1868.

The existence of such a custom as arsenic eating, in its literal sense, has more than once been doubted, but all who have travelled over Styria and other places where the habit prevails have convinced themselves that the facts have not been overstated. For example, Dr. Maclagan, in company with Dr. J. T. Rutter,† visited Styria in 1865, and having carefully weighed 5 or 6 grains of arsenic, saw these doses actually swallowed by two men. On collecting their urine, about two hours afterwards, abundant quantitative evidence of its presence was found; but in neither of the men were there the slightest symptoms of poisoning. It is obvious that the existence of such a habit might seriously complicate any inquiry into arsenical poisoning in these regions.

Manner of Introduction of Arsenic.—Arsenious acid exerts a poisonous action, whether it is taken by the stomach, or introduced into the system by any other channel whatever. The differences in the symtoms produced by external application (as through a wound), and by swallowing arsenious acid in substance or in solution, are not so marked as might be expected. It was probably Hunter who first distinctly recognised the fact that arsenic, even when introduced outwardly by application to an abraded surface, exert a specific effect on the mucous membrane of the stomach. Brodie* states, "Mr. Home informed me that in an experiment made by Mr. Hunter himself, in which arsenic was applied to a wound in a dog, the animal died in twenty-four hours, and the stomach was found to be considerably inflamed. I repeated this experiment several times, taking the precaution of always applying a bandage to prevent the animal licking the wound. The result was that the inflammation of the stomach was commonly more violent and more immediate than when the poison was administered internally, and that it preceded in appearance the inflammation of the wound."

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* Tardieu. *Op. cit.*

† *Edin. Med. Journal*, April, 1865; *Brit. and For. Med. Chir. Journ.*, Oct. 1865.

Cases of Poisoning by the External Application of Arsenic.—The mass-poisoning by the external use of violet powder to infants, which occurred in England some few years ago, is still fresh in public memory. Two deaths from this cause were established by coroners' inquests.† Dr. Tidy found the violet powders used in the two cases to have the following composition :—

	1. Per Cent.	2. Per Cent.
Arsenious Acid,	38·5	38·3
Starch (Potato),	54·8	55·4
Magnesia, &c.,	6·7	6·3‡

Although the children were poisoned by absorption through the skin (unless it is allowed that some may have found its way in the form

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* Two recipes were handed in at the coroner's inquest which pretty fairly represent the composition of commercial violet powder :—

First Quality, sold at 7s. per gross.

Starch Powder,	28 lbs.
Magnesia,	1½ lb.
Orris-root,	1 lb.
Violet Perfume,	1 oz.
Essence of Roses,	5 drops.

Second Quality, sold at 6s. per gross.

Terra Alba (Sulphate of Lime),	14 lbs.
Potato Starch,	21 lbs.
Magnesia,	3 lbs.
Orris-root,	1½ lb.
Violet Perfume,	1½ oz.
Essence of Roses,	5 drops.

† *Phil. Trans.*, 1812.

‡ "Gleanings in Toxicology," by C. Meymott Tidy, M.B.—*Lancet*, Aug. 21 1878.

of arsenical dust into the throat, or, what is still more probable, that the infants may from time to time have seized the puff-ball and *sucked* it), the large quantity of ·421 grm. (6·5 grains) of arsenious acid was separated in the one case, and ·194 grm. (3 grains) in the other. In these cases arose the question which is sure to recur in legal inquiries into poisoning by absorption—viz., whether the poison lying on the surface and folds of the skin could not have been mixed during the *post-mortem* examination with the organs of the body ? In these particular cases special care appears to have been taken, and the answer was satisfactory. It is not amiss, however, to call attention to the extreme precaution which such instances necessitate.

A woman, aged fifty-one, had used a solution of arsenious acid to cure the itch ; erysipelas of the body, however, followed, and she died after a long illness—one of the symptoms noted being trembling and paresis of the limbs.* In a case recorded by Desgranges,† a young chambermaid had applied to the unwounded scalp an arsenical ointment for the purpose of destroying vermin. She also suffered from a severe erysipelas, and the hair fell off. Quacks have frequently applied various arsenical pastes to ulcers and cancerous breasts with a fatal result. Instances of this abound ; in one, a charlatan applied to a chronic ulcer of the leg an arsenical caustic ; the patient showed symptoms of violent poisoning, and died on the sixth day.‡ In another, a lady suffering from some form of tumour of the breast, applied to an unqualified practitioner, who made from fifteen to twenty punctures with a lancet in the swelling, covered a piece of bread with an arsenical compound, and applied the bread thus prepared to the breast. Twelve hours afterwards symptoms of violent gastric irritation commenced ; and vomiting and a sanguinolent diarrhœa followed, with death on the fifth day. Arsenic was found in all the organs.§ Such examples might be multiplied. Arsenic has been in more than one case introduced criminally into the vagina with a fatal result.‖ Foberé, *e.g.*, has recorded the case of a maid-servant who poisoned her mistress by intentionally administering several arsenical enemata.* Arsenious acid again has been respired in the form of vapour. One of the best instances of this is recorded by Taylor, and was the subject of a trial at the York Lent Assizes, 1864. The prisoner placed some burning pyrites at the doorway of a small room, in which there were eight children, including an infant in the cradle. The other children were removed speedily, but the infant was exposed to the vapour for an hour; it suffered from vomiting and diarrhœa, and died in twenty-four hours. There was slight inflammation of the stomach and intestines, the brain and lungs were congested, and the lining membrane of the trachea of a bright red colour. Arsenic was detected in the stomach, in the lungs, and spleen. The pyrites contained arsenic, and the fatal fumes were in effect composed of sulphurous and arsenious acids.

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* Belloc, *Méd Lég.*, t. iv., p. 124.

† *Recueil de la Soc. de Méd de Paris*, t. vi., p. 22, An. vii.; also Tardieu, *Etude Méd Légale, sur l'Empoisonnement*, Obs. xxvii., p. 457.

‡ Mean, *Bibliothèque Méd.*, t. lxxiv., 1821, p. 401.

§ Tardieu, *Op. cit.*, obs. xxix.; Dr. Vernois, *Ann. d'Hyg. et de Méd. Lég.*, t. xxxvi., 1st ser., p. 141, 1846.

‖ Ansiaulx, *Clinique Chirurgicale.* Mangor (*Acta Societ. Reg. Hafniens*, iii., p. 178) gives the case of a man who poisoned his three wives successively with arsenic—the two last by introducing into the vagina a powder composed of flour and arsenic. Another similar case is related by Brisken. Mangor made experiments on mares, showing that when arsenic is applied to the vagina, death may result from inflammation.

The use of paper covered with arsenical pigments, as wall-paper in bed and sitting rooms, has often produced disease; sometimes from the arsenical dust being breathed, sometimes from the production of arsine (arseniuretted hydrogen), and possibly from some uninvestigated volatile compound. Recently I examined a wall-paper, which, on analysis, yielded arsenic equal to 8 grains of arsenious acid in every square foot; it was a portion of a wall-paper from the bedroom of a gentleman, who had for many months suffered from an obscure malady, which had baffled the eminent men whom he had consulted. The paper in question had a few green leaves on a quiet drab-coloured ground. On the discovery of its arsenical properties, he removed to another bedroom, with immediate and marked improvement in health. Most analysts in practice have met with similar instances, and a considerable number are on record in medical literature.

Forms of Arsenical Poisoning.—There are at least four distinct forms of arsenical poisoning—viz., an acute, subacute, a nervous, and a chronic form.

Acute Form.—All those cases in which the inflammatory symptoms are severe from the commencement, and in which the sufferer dies within twenty-four hours, may be called acute. The commencement of the symptoms in these cases is always within the hour; they have been known, indeed, to occur within eight minutes, but the most usual time is from twenty minutes to half an hour. There is an acrid feeling in the throat, with nausea; vomiting soon sets in, the objected matters being at first composed of the substances eaten; later they may be bilious or even bloody, or composed of a whitish liquid. Diarrhœa follows and accompanies the vomiting, the motions are sometimes like those met with in ordinary diarrhœa and English cholera, and sometimes bloody. There is coldness of the extremities, with great feebleness, and the pulse is small and difficult to feel. The face, at first very pale, takes a bluish tint, the temperature falls still lower; the patient sinks in collapse, and death takes place in from five to twenty hours after the taking of the poison.

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* *Méd. Légale*, iv.

There can scarcely be said to be any clinical feature which distinguishes the above description from that of cholera; and supposing that cholera were epidemic, and no suspicious circumstances apparently present, there can be little doubt that a most experienced physician might mistake the cause of the malady, unless surrounding circumstances give some hint or clue to it. In the acute form diarrhœa may be absent, and the patient die, as it were, from "shock." This was probably the cause of death in a case related by Casper,* that of Julius Bolle, poisoned by his wife. He took an unknown quantity of arsenic in solution at seven in the morning, and in about three-quarters of an hour afterwards suffered from pain and vomiting, and died in little more than three hours. There were no signs of inflammation in the stomach and intestines, but from the contents of the stomach were separated ·0132 grm. of arsenious acid, and ·00513 grm. from pieces of the liver, spleen, kidneys, lung, and blood. The dose actually taken is supposed not to have been less than ·388 grm. (6 grains).

The Subacute Form.—The subacute form is that which is most common; it exhibits some variety of phenomena, and individual cases very much in the matter of time. The commencement of symptoms is, as in the most acute form, usually within the hour, but exceptions to this rule occur. In a case quoted by Taylor,† and recorded by M. Tonnelier, the poison did not cause any marked illness for eight hours; it was found on *post-mortem* examination, that a cyst had been formed in the stomach which sheathed the arsenic over, and in some degree explained this delay. In another case, again, ten hours elapsed, and this is considered to be the maximum period yet observed. As, with the acute form, there is a feeling of nausea, followed by vomiting, which continues although the stomach is quite empty; at first the ejected matter is a watery fluid, but later it may be streaked with blood. The tongue is thickly coated; there is great thirst, but the drinking of any liquid (even of ice-cold water) increases the vomiting. Nearly always pain is felt in the epigastrium, spreading all over the abdomen, and extending to the loin (which in tense and tender on pressure). Deglutition is often painful, and is accompanied by a sort of spasmodic constriction of the pharyngeal muscles. Diarrhœa follows the vomiting, and has the

* Case 188 in Casper's *Handbuch*.

† Taylor's "Principles and Practice of Jurisprudence," vol. i., p. 251. Flandin, vol. i., p. 535.

same characters as that previously described; occasionally, however, this feature is absent. In the case recorded by Martineau* a man, aged twenty-five, was seized at 10 a.m. suddenly with vomiting, which persisted all that day and the next, during which time the bowels were obstinately confined. On the second day a purgative was administered, whereupon diarrhœa sat in, and continued until his death, which occurred in about two days and sixteen hours from the commencement of the symptoms. This case is also remarkable from the absence of pain or tenderness of the abdomen.

In subacute cases the urine has several times been suppressed, and it is generally scanty and red in colour. Irregularity of the heart's action and feebleness are tolerably constant phenomena. As the end approaches, there is excessive muscular weakness, the face is pale, the eyes hollow; the mucous membranes first, and then the skin, take a bluish tint; the skin itself is covered with perspiration, and there has been noticed a peculiar odour, which has been likened to arsine (arseniuretted hydrogen). The respiration is troubled, convulsive movements of the limbs have been observed, and cramps in the calves of the legs; death follows in a variable time—from twenty-four hours to several days. In certain cases there is a curious remission after violent symptoms, the patient rallies and seems to have recovered; but the appearance is deceptive, for the symptoms recur, and death follows. Recovery may also take place partially from the primary effects, and then inflammatory changes in the stomach, &c., set in, with fever, and the ordinary symptoms which are common to all internal inflammation.

A single dose of arsenious acid may cause a prolonged and fatal illness, one of the best known examples being that of the suicide of the Duc de Praslin,* who took with suicidal intent, on Wednesday, August 18, 1847, a dose of arsenious acid. The exact time of the act could not be ascertained, but the first effects appeared at 10 p.m.; there were the usual signs of vomiting, followed on the next day by diarrhœa, fainting, and extreme feebleness of the pulse. On Friday there was a remission of the symptoms, but great coldness of the limbs, intermittency and feebleness of the heart's action, and depression. On Saturday there was slight fever, but no pain or tenderness in the abdomen, vomiting, or diarrhœa; on this day no urine was passed. On the Sunday he complained of a severe constriction of the throat, and deglutition was extremely painful; thirst was extreme, the tongue, intensely red, as well as the mucous membrane of the mouth and pharynx, and the patient had a sensation of burning from the mouth to the anus. The abdomen was painful and distended, the heat of the skin was pronounced, the pulse frequent and irregular—sometimes strong, at others feeble, the bowels had to be relieved by injections, the urine was in very small quantity; during the night there was no sleep. The duke died at 4.35 a.m., on Tuesday the 24th, the sixth day; intelligence was retained to the last. As the end approached the respiration became embarrassed, the body extremely cold, and the pulse very frequent.

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* Tardieu, *Op. cit.*, obs. xix.

† Tardieu, *Rélation Médico-Légale de l'Assassinat de la Duchesse de Praslin Ann. d'Hy. Pub. et de Médico-Lég.*, 1847, t. xxxviii., p. 390; also *Op. cit.*, obs xi.

In the nervous form the ordinary vomiting and purging are either entirely suppressed, or present in but feeble degree; and under this heading are classed the rare cases in which, in place of the ordinary symptoms, affections of the nervous system predominate. Narcotism, paresis, deepening into paralysis, delirium, and even acute mania, as well as epileptiform convulsions, have all been recorded. In short, the symptoms show so much variety, that an idea of the malady produced in this very rare form can only be obtained by studying the clinical history of cases which have presented this aspect. In a case recorded by Guilbert,* a man, thirty-five years of age, had swallowed a solution of arsenic, half of which was immediately rejected by vomiting. A little while afterwards his respiration became laborious; the eyes were bathed with tears, which were so acrid as to inflame the eyelids and the cheeks; the muscles of the face were from time to time convulsed; he perspired much, and the perspiration had a fœtid odour; there was some diarrhœa, the urine was suppressed, and from time to time he was delirious. Afterwards the convulsions became general, and the symptoms continued with more or less severity for five days. On the sixth a copious miliary eruption broke out, and the symptoms became less severe. The eruption during fifteen days every now and again reappeared, and at the end of that time the patient was convalescent, but weak, liable to ophthalmias, and had a universal trembling of the limbs.

In one of Brodie's† experiments on rabbits, 7 grains of arsenious acid were inserted in a wound in the back; the effect of which was to paralyse the hind legs. In other experiments on animals, paralysis of the hind legs has been frequently noticed, but paralysis certainly is rare in man; in the case, however, recorded by Barrier,‡ of the five men who took by mistake a solution of arsenious acid, one of them was found stretched on the ground with the inferior extremities paralysed.

In a case of "mass" poisoning reported by Dr. Coqueret,§ three persons ate by mistake an unknown quantity of arsenious acid—two of them only suffered slightly, but the third severely, vomiting occurring almost immediately, and continuing with frequency until the end of the fourth day. Two hours after swallowing the poison, the patient took the hydrated oxide of iron as an antidote. On the sixth day there was stupor and a semi-delirious state, with an eruption of a pustular character compared to that of the small-pox. These symptoms continued more or less until the fifteenth day, when they diminished, and ultimately the patient recovered. In a case related by Tardieu,* in which a person died on the eleventh day from the effects of the poison; towards the end, as a specially marked symptom, there was noted hyperæsthesia of the inferior extremities, so that the least touch was painful.

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* *Journal de Van der Monde*, 1756, t. iv., p. 353. Tardieu, *Op cit.*, obs. xiii., p. 430.

† The Action of Poisons, *Phil. Trans.*, 1812.

‡ *Journ. de Médecine*, 1783, p. 353. Tardieu, *Op. cit.*, obs. xiv., p. 431.

§ *Journ. de Connaiss. Méd. Chirurg.*, 1839, p. 155. Tardieu, *Op. cit.*, obs. xv., p. 432.

Absence of Symptoms.—In a few cases there have been a remarkable absence of symptoms, and this both in man and animals. Seven horses were fed with oats accidentally mixed with arseniate of soda. The first succumbed three hours after taking the poison, without having presented any symptom whatever; he fell suddenly, and in a short time expired.† It is related by Orfila,‡ that a woman, aged twenty-seven, expired in about twelve hours from a large dose of arsenious acid; there were the usual *post-mortem* appearances, but in life no sign of pain, no vomiting, and but little thirst.

Slow Poisoning.—Slow poisoning has been caused accidentally by arsenical wall-paper, in the manufacture of arsenical pigments, by the admixture of small quantities of arsenic with salt or other condiments, and repeated small doses have been used for criminally producing a fatal illness intended to simulate disease from natural causes. The illness produced by small intermittent doses may closely resemble in miniature, as it were, those produced by large amounts; but, on the other hand, they may be different and scarcely to be described otherwise than as a general condition of ill-health and *malaise.* In such cases there is loss of appetite, feebleness, and not unfrequently a slight yellowness of the skin. A very constant effect seen, when a solution of arsenious acid is given continuously for a long time, is an inflammation of the conjunctivæ, as well as of the nasal mucous membrane—the patient complains of "always having a cold." This inflammatory action also affects the pharynx, and may extend to the air-passages, and even to the lung-tissue. At the same time there is often seen an exanthem, which has received a specific name—"*eczema arsenicale.*" Salivation is present, the gums are sore, at times lacerated. In chronic poisoning by arsenic, nervous symptoms are almost constant, and exhibit great variety; there may be numbness or the opposite condition, hyperæsthesia, in the extremities. In certain cases fainting, paresis, paralysis, and sometimes convulsions occur; towards the end a sort of hectic fever supervenes, and the patient dies of exhaustion.

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* *Op. cit.*, obs. xvii., p. 434.

† Bouley (Jeune), *Ann. d'Hyg. et de Médico-Lég.*, 1834., t. xii., p. 393.

‡ Tome i., obs. iv., p. 314.

Post-mortem Appearances in Animals.—P. Hugo * has recently made some minute researches as to the pathological appearances met with in animals. His experiments were made on seven dogs, eight guinea-pigs, five rabbits, two pigeons, and five cats—all poisoned by arsenious acid. According to Hugo, so far as these animals were concerned, changes were more constant in the intestine than in the stomach.

Stomach.—Changes in the mucous membrane were especially noticed in the great curvature and towards the pylorus; the pylorus itself, and a part of the cardiac portion, remained unchanged. The mucous membrane in dogs and cats was red, with a tinge of blue—in many cases the redness was in streaks, with injection of the capillaries. The stomach of plant-eaters was less altered, and a microscopical examination of the mucous tissues did not show any fatty change.

The Intestines.—In dogs and cats changes were evident; in rabbits and guinea-pigs they were not so marked, but the intestines of the last were extremely tender and brittle, very moist, and filled with a slimy, serous, grey-white fluid; nevertheless, the changes in all these animals appear to be of essentially the same nature. The most striking effect is the shedding of a pseudo-membrane; in quite recent cases there is a layer of from 1 to 1½ mm. wide of a transparent, frog-spawn-like jelly streaking the intestine. In later stages it becomes thicker, while occasionally it resembles a diphtheritic exudation. The mucous membrane itself is deep purple-red, showing up by the side of the pseudo-membrane. With regard to the villi, the epithelial layer is detached, and the capillary network filled with blood and enlarged.

The Liver.—Hugo met only occasionally with fatty degeneration of the liver, but there was marked steatose of the epithelium of the gall-bladder of dogs. A fact not prominently noticed before, is (at all events, in dogs) a serous transudation into the pleural sac and acute œdema of the lungs; the exudation may be excessive, so that more than 100 cc. of serous fluid can be obtained from the thorax; there is also usually much fluid in the pericardium. In two of Hugo's experiments, there was fluid in the cerebral ventricles; and in all there was increased moisture of the brain substance with injection of the capillary vessels, especially of the pia.

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* *Beiträge zur Pathologie der acuten Arsenikvergiftung.*, *Archiv für Exper. Pathol. u. Pharmakol.* Leipzig, 1882.

Post-mortem Appearances in Man.—When arsenious acid is swallowed in substance or solution, the most marked change is that in the mucous membrane of the stomach and intestines; and, even when the poison has been absorbed by the skin, or taken in any other way, there may be a very pronounced imflammatory action. On the other hand, this is occasionally absent. Orfila* relates a case in which a man died in thirteen hours after having taken 12 grms. of arsenious acid:—"The mucous membrane of the stomach presented in its whole extent no trace of inflammation, no redness, and no alteration of texture." Many other similar cases are on record; and, according to Harvey's statistics, in 197 cases, 36 (about 18·2 per cent.) presented no lesion of the stomach.

The usual changes produced by arsenious acid may be studied in the museums of the London hospitals. In Guy's Hospital Museum I found three preparations. In preparation 1798^{32} is seen a large stomach with the mucous membrane at certain points abraded, and at the great curvature the whole coats are thinned; it is also somewhat congested. In preparation 1798^{64} is a portion of coagulated lymph, from the stomach of a lad aged fourteen, who had taken accidentally a piece of cheese charged with arsenious acid, prepared for the purpose of destroying rats. He lived twenty-eight hours, and presented the ordinary symptoms. The lymph has a membranous appearance, and the rugæ of the stomach are impressed upon it. It is said when recent to have presented numerous bright bloody spots, although there was no visible breach of substance on the surface of the stomach. The mucous membrane of the stomach is stated to have been injected, and there was also diffuse injection of the duodenum. Preparation 1798^{80} is the stomach of a person who survived thirteen hours after taking a fatal dose of arsenious acid; and in the same museum there is a wax model of the appearances which the fresh preparation exhibited, showing a large oval patch coated with mucous and the poison. The stomach was intensely inflamed, the cæcum injected. The rest of the intestine was healthy.

In the museum of University College there are two preparations, one † exhibiting intense swelling and congesting of the gastric mucous membrane, which is of a perfectly vermilion colour. Another preparation (No. 2868) shows the effect of a small dose of arsenic on the stomach; there are spots of arborescent extravasation, and slight congestion of the summit of the rugæ, but in other respects it is normal. There is also a cast of Peyer's patches from the same case, showing great prominence of the glands, with some injection of the intestinal mucous membrane.

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* Tome i., obs. v.

† This preparation at the time of my visit had no number.

In St. Thomas' Hospital there is an interesting preparation (No. 8) showing the gastric mucous membrane dotted all over with minute ulcers, none of which have an inflammatory zone.* I have not, however, seen in any museum a preparation of the curious emphysematous condition of the mucous membrane, which has more than once been met with. For example, in a case related by Tardieu,† Schwann, a labourer, died from the effects of arsenic in thirty-six hours. The autopsy showed that the mucous membrane of the stomach and small intestine was covered with a pasty coating, and was elevated in nearly its whole extent by the bullæ filled with gas, forming true emphysematous swellings which encroached upon the diameter of the intestine. There was neither redness nor ulceration, but the mucous membrane was softened.

I also saw a few years ago at Barnard Castle an autopsy made on a gentleman who died from arsenic. In this case the mucous membrane of the stomach presented a peculiar appearance, being raised here and there by little blebs, and very slightly reddened.

The inflammatory and other changes rarely affect the gullet. Brodie ‡ never observed inflammation of the œsophagus as an effect of arsenic; but, when arsenic is swallowed in the solid state, as in the suicide of Soufflard, graphically described by Orfila,§ it may be affected. In Soufflard's case there was a vivid injection of the pharynx and gullet.

In many instances, when the arsenic has been taken in the solid form, the crystals with mucous and other matters adhere to the lining membrane. I have seen in the stomach of a horse, poisoned by an ounce of arsenic, an exquisite example of this. The inflammatory changes may be recognised many months after death owing to the antiseptic properties of arsenic; nevertheless, great caution is necessary in giving an opinion, for there is often a remarkable redness induced by putrefactive changes in healthy stomachs. Casper‖ on this point very justly observes—"If Orfila quotes a case from Lepelletier, in which the inflammatory redness of the mucous membrane of the stomach was to be recognised after nine months' interment, and if Taylor cites two cases in which it was observed nineteen and twenty-one months after death respectively, this is in contradiction of all that I, on my part, have seen in the very numerous exhumed corpses examined by me in relation to the gradual progress of putrefaction and of saponification, and I cannot help here suspecting a confusion with the putrefactive imbibition redness of the mucous membrane."

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* In a case related by Orfila, t. i., obs. xv., death resulted from the outward application of arsenic; the mucous membrane of the stomach was natural in colour, but there were four ulcers, one of which was fifty centimetres in diameter

† *Op. cit.*, obs. i., p. 468.

‡ *Phil. Trans.*, 1812.

§ T. i., p. 319.

‖ *Handbuch*, vol. ii., p. 420.

If examined microscopically, the liver and kidneys show no change, save a fatty degeneration and infiltration of the epithelial cells. In the muscular substance of the heart, under the endocardium, there is almost constantly noticed ecchymosis. In the most acute cases, in which a cholera-like diarrhœa has exhausted the sufferer, the blood may be thickened from loss of its aqueous constituents, and the whole of the organs will present that singularly dry appearance, found in all cases in which there has been a copious draining away of the body fluids. In the narcotic form of arsenical poisoning, the vessels of the brain have been noted as congested, but this congestion is neither marked nor pathognomonic. Among the rare pathological changes may be classed glossitis, in which the whole tongue has swollen, and is found so large as almost to fill the mouth. This has been explained, in one case, as caused by solid arsenious acid having been left a little time in the mouth before swallowing it. On the other hand, it has also been observed when the poison has been absorbed from a cutaneous application. When arsenic has been introduced into the vagina, the ordinary traces of inflammatory action have been seen, and, even without direct contact, an inflammation of the male and female sexual organs has been recorded, extending so far as gangrene. As a rule, putrefaction is remarkably retarded, and is especially slow in those organs which contain arsenic; so, that if the poison has been swallowed, the stomach will retain its form, and, even to a certain extent, its natural appearance for an indefinite period. In corpses long buried of persons dying from arsenical poisoning, the ordinary process of decay gives place to a saponification, and such bodies present a striking contrast to others buried in the same graveyard. This retardation of putrefaction is what might, *à priori*, be expected, for arsenic has been long in use as a preservative of organic tissues.

Physiological Action of Arsenic.—The older view with regard to the essential action of arsenic was, without doubt, that the effects were mainly local, and that death ensued from the corrosive action on the stomach and other tissues—a view which is in its entirety no longer accepted; nevertheless, it is perfectly true that arsenic has a corrosive local action: it will raise blisters on the skin, will inflame the tongue or mucous membranes with which it comes in contact; and, in those rapid cases in which extensive lesions have been found in the alimentary canal, it can hardly be denied that instances of death have occurred more from the local than the constitutional action. In the vast majority of cases, however, there is certainly insufficient local action to account for death, and we must refer the lethal result to a more profound and intimate effect on the nervous centres. The curious fact that, when arsenic is absorbed from a cutaneous surface or from a wound, the mucous membrane of the stomach inflames, is explained by the absorption of the arsenic into the blood and its separation by the mucous membrane, in its passage, exerting an irritant action. The diarrhœa has been referred to a paralysis of the splanchnic nerves, but Esser considers it due to an irritation of the ganglia in the intestinal walls. Binz has advanced a new and original theory as to the action of arsenious acid; he considers that the protoplasm of the cells of many tissues possess the power of oxidising arsenious acid to arsenic acid, and this arsenic acid is again, by the same agency, reduced to arsenious acid; in this way, by the alternate oxidation and reduction of the arsenious acid, the cells are decomposed, and a fatty degeneration takes place. Thus arsenic causes fatty changes in the liver, kidney, and other cells by a process analogous to the action of phosphorus. A notable diminution of arterial pressure has been observed. In an experiment by Hugo* ·03 grm. of As_2O_3 was injected intravenously, the normal arterial pressure being 178 mm. Ten minutes after injection the pressure sank to 47 mm.; in sixteen minutes it again rose to 127 mm.

Elimination of Arsenic.—Arsenic is separated especially by the urine,† then through the bile, and by the perspiration. It is found in the urine first after from five to six hours, but the elimination from a single dose is not finished till a period of from five to eight days; it has often been looked for twelve days after taking it, but very seldom found. Accumulative action of arsenic never occurs. Hebra has given, in skin diseases, during many months, as much as 12 grms. of arsenic without evil result.

Antidote and Treatment.—In any case in which there is opportunity for *immediate* treatment, ferric hydrate should be administered as an antidote. Ferric hydrate converts the soluble arsenious acid into the insoluble ferric arseniate, the ferric oxide being reduced to ferrous oxide It is necessary to use ferric hydrate recently prepared, for if dried it changes into an oxyhydrate, or even if kept under water the same change occurs, so that (according to the experiments of Messrs. T. &. H. Smith) after four months the power of the moist mass is reduced to one-half, and after five months to one-fourth.

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* *Op. cit.*

† An old experiment of Orfila's has some practical bearings, and may be cited here. A dog was treated by ·12 grm. of arsenious acid, and supplied plentifully with liquid to drink; his urine, analysed from time to time during ten days, gave abundant evidences of arsenic. On killing the animal by hanging on the tenth day, no arsenic could be detected in any of the organs of the body; it had been, as it were, washed out.

It is obvious that ferric hydrate is not in the true sense of the word an antidote, for it will only act when it comes in contact with the arsenious acid; and, when once the poison has been removed from the stomach by absorption into the tissues, the administration of the hydrate is absolutely useless. Ferric hydrate may be readily prepared by adding strong ammonia to the solution or tincture of ferric chloride, found in every medical man's surgery and in every chemist's shop, care being taken to add no caustic excess of ammonia; the liquid need not be filtered, but at once administered. With regard to other methods of medical treatment, they are simply those suggested by the symptoms and well-known effects of the poison. When absorbed, the drinking of water in excess cannot but assist its elimination by the kidneys.

Detection of Arsenic.—The analyst may have to identify arsenic in substance, in solution, in alloys, in wall-paper, in earth, and in various animal, fatty, resinous, or other organic matters.

Arsenious Acid in Substance.—The general characters of arsenious acid have been already described, and are themselves so marked as to be unmistakable. The following are the most conclusive tests:—

(1.) A small fragment placed in the subliming cell (p. 229), and heated to about the temperature of 137·7° (286°F), at once sublimes in the form of an amorphous powder, if the upper glass disc is cool; but if heated (as it should be) to nearly the same temperature as the lower, characteristic crystals are obtained, remarkable for their brilliancy and permanency, and almost always distinct and separate. The prevailing form is the regular octahedron, but the rhombic dodecahedron, the rectangular prism, superimposed crystals, half crystals, deep triangular plates like tetrahedra, and irregular and confused forms, all occasionally occur.

(2.) A beautiful and well-known test is that of Berzelius:—A small hard-glass tube is taken, and the closed end drawn out to the size of a knitting-needle. Within the extreme point of this fine part is placed the fragment (which may be no more than a milligramme), and a splinter of charcoal, fine enough to enter freely the narrow part, as shown in the figure. The portion of the tube containing the charcoal (*e*) is first heated until it glows, and then the extreme end; if arsenic is present, a mirror-like coating is easily obtained in the broader portion of the

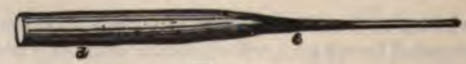

Fig. 18.

tube (*d*). That this coating is really arsenical can be established by the behaviour of metallic crusts of arsenic towards solvents (as given at p. 499). The portion of the tube containing the crust may also be broken up, put in a very short, wide test-tube (the mouth of which is occupied by a circle of thin microscopic glass) and heated, when the arsenic will sublime on to the glass disc, partly as a metal and partly as crystalline arsenious acid.

(3.) Arsenious acid, itself inodorous, when heated on coal, after mixing it with moist oxalate of potash, evolves a peculiar garlic-like odour. To this test oxide of antimony adulterated with arsenic will respond, if there is only a thousandth part present. Simply projecting arsenious acid on either red-hot charcoal or iron produces the same odour.

(4.) A little bit of arsenious acid heated in a matrass with two or three times its weight of acetate of potash, evolves the unsupportable odour of kakodyl.

Arsenites and Arseniates, mixed with oxalate of soda and heated in a matrass, afford distinct mirrors, especially the arsenites of the earths and silver; those of copper and iron are rather less distinct.

Sulphides of Arsenic are reduced by any of the processes described on p. 540 *et seq.*

In Solution.—An acid solution of arsenious acid gives, when treated with SH_2, a canary-yellow precipitate, soluble in ammonia, carbonate of ammonia, and bisulphite of potash, and also a metallic sublimate when heated in a tube with the reducing agents in the manner described at p. 540. By these properties the sulphide is distinguished and, indeed, separated from antimony, tin, and cadmium.

The sulphides of tin and cadmium are certainly also yellow, but the latter is quite insoluble in ammonia, while the former gives no metallic sublimate when heated with reducing substances.

The sulphide of antimony, again, is orange, and quite insoluble in potassic bisulphite, and scarcely dissolves in ammonia.

A small piece of sodium amalgam placed in a test-tube or flask containing an arsenic-holding liquid, produces in a short time arseniuretted hydrogen, which will blacken a piece of paper, soaked in nitrate of silver, and inserted in the mouth of the flask. This is certainly the most convenient test for arsenic. If the liquid be previously made alkaline, no antimoniuretted hydrogen (*stibine*) is given off.

Marsh's Original Test for Arsenic consists in evolving nascent hydrogen by zinc and sulphuric acid, and then adding the liquid to be tested. The apparatus for Marsh's test, in its simplest form, consists of a flask provided with a cork conveying two tubes, one a funnel reaching nearly to the bottom of the flask; the other a delivery tube, which is of some length, is provided with a chloride of calcium bulb,* and towards the end is turned up at right angles, the end being narrowed. By evolving hydrogen from zinc and sulphuric acid, and then adding portions of the liquid through the funnel, arseniuretted hydrogen in a dry state is driven along the leading tube, can be ignited on its issue, and on depressing a piece of cold porcelain, a dark metallic spot of arsenic is obtained.† Or, if any portion of the tube be made red-hot, the metal is deposited in the same way as a ring. The apparatus admits of much complication and variety. One of the most useful additions is, perhaps, the interposition of a small gasometer. This consists of a cylindrical glass vessel with entrance and exit tubes, open at the bottom, immersed in water in a larger vessel, and counterpoised by weights and rollers, exactly like the large gasometers used at gasworks; the exit tube must have a stop-cock, and the gas must pass through sulphuric acid in order to dry it thoroughly.

M. Blondlot has observed ‡ that if pure zinc, a weak solution of arsenious acid, and a sulphuric acid containing nitric acid or nitrous compounds, be mixed together, the arsenic passes into a solid hydrate, which is deposited on the surface of the zinc. Certain organic substances (such as sugar, gum, &c.) prevent this formation of solid hydrate. Thus, in two ways, the analyst may be deceived—under the above conditions, the zinc may be arsenical, and yet pure hydrogen be evolved until the very moment in which the liquid to be tested is added ; or, on the other hand, if the liquid to be tested and the acid itself contain nitrous compounds, no arsenic may come off, although arsenic be actually present. The formation of the solid hydrate in the original testing may always be prevented by the addition of a little pure cane sugar ; but in operating on liquids of unknown composition, Blondlot's observation shows clearly, that if no result is obtained from Marsh's test as ordinarily applied, arsenic may yet be present. This objection does not hold good in the evolution of hydrogen by galvanism, nor, so far as is known, when sodium amalgam is used.

The precautions to be observed in Marsh's test are :—

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* Otto recommends the first half of the drying tube connected with the development flask to be filled with caustic potash, the latter half with chloride of calcium (*Ausmittelung der Gifte*). Dragendorff approves of this, but remarks that it should be used when arsenic alone was searched for, since caustic potash decomposes stibine. The potash fixes SH_2, and prevents the formation of chloride of arsenic.

† For identification of arsenical films, see p. 499.

‡ Blondlot: "Transformation de l'arsenic en hydrure solide par l'hydrogène naissant sous l'influence des composés nitreux."—*Jour. de Pharm. et de Chim.*, 3e ser., t. xliv., p. 486.

(1.) Absolute freedom of the reagents used from arsenic, antimony,* and other impurities.

(2.) The sulphuric acid should be diluted with five times its weight of water, and if freshly prepared should be cooled before use. Strong acid must not be employed.†

(3.) The fluid to be tested should be poured in little by little.

(4.) Nitrous compounds, nitric acid, hydrochloric acid, chlorides, are all more or less prejudicial.

(5.) The gas should come off regularly in not too strong a stream, nor out of too small an opening.

(6.) The gas should pass through a red-hot tube at least one hour, if no stain is at once detected.

(7.) A little pure bichloride of platinum solution may be added, without injury to the zinc, if the gas comes off too slowly.‡

The characteristics of the metallic stains which may occur either on glass or porcelain in the use of Marsh's test, may be noted as under :—

MIRROR OR CRUST OF ARSENIC.	MIRROR OR CRUST OF ANTIMONY.
Is deposited at a little distance from the flame.	Is deposited close to the flame, and on both sides of it, and is therefore notched.
An arsenical stain is in two portions, the one brownish, the other a glittering black.	The stain is tolerably homogeneous, and usually has a tin-like lustre.
On heating, it is rapidly volatilised as arsenious acid.	Volatilisation very slow ; no crystalline sublimate obtainable.
On transmission of a stream of SH_2, whilst immediately behind the stain a gentle heat is applied, the arsenic is changed to yellow sulphide ; § if dry ClH is now trans-	The same process applied in the case of antimony produces the orange or black sulphide ; and on passing dry ClH, chloride of antimony volatilises without the appli-

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* With regard to purity of reagents, Sonnenschein states that he has once found chlorate of potash contaminated with arsenic.—Sonnenschein : *Gericht. Chemie*, p. 139.

† M. A. Gautier uses sulphuric acid diluted with five times its weight of water ; when the hydrogen has displaced the air, he adds to the arsenical matter 45 grms. of this acid and 5 grms. of pure sulphuric acid.—*Bull de la Société Chim. de Paris*, 1875, t. xxiv.

‡ A solution of sulphate of copper has been recommended ; according to Gautier, two-thirds of the arsenic in such a case are retained.

§ It is desirable to dissolve away the free sulphur often deposited with the arsenical sulphide by bisulphide of carbon.

mitted, the arsenical sulphide is unchanged.	cation of heat.
Chloride of lime dissolves the arsenic completely.	Antimony not affected.
Protochloride of tin has no action on metallic arsenic.	Dissolves slowly but completely the antimony stain.
The arsenic stain, dissolved in *aqua regia,* or ClH and chlorate of potash, and then treated with tartaric acid, ammonia, and magnesia mixture, gives a precipitate of ammonia magnesian arseniate.*	No precipitate with antimony.

Reinsch's Test is a simple electrolytic method of depositing arsenic on copper :—A piece of pure bright copper foil or gauze is attached to a platinum wire, and the copper immersed in the liquid to be tested, which is then boiled. The liquid must be distinctly acid, and should be contained in a flask, the mouth of which is conveniently partially closed by a funnel, the free end of the wire reaching well out of the flask, so that the copper may be from time to time examined. The boiling in very dilute solutions should be prolonged, but it need not be violent—a gentle simmering is all that is required. The copper, if a very minute quantity of arsenic is present, will have a greyish stain upon it; with larger quantities a somewhat glistening black-lead appearance is produced. Mercury, sulphur, selenium, and antimony all stain copper.

On heating the stained copper in the subliming cell (p. 229) or in a tube, if mercury is present it will sublime in microscopic globules. Sulphide of copper can be rubbed off with the fingers, but the arsenical stain, on the contrary, is a true alloy, consisting, according to Lippert† of one atom of arsenic and five of copper. The arsenical stain, again, dissolves in caustic ammonia; the sulphide of copper does not do so. The arsenical stain also dissolves in a mixture of equal parts of water and ClH with development of hydrogen, an action which does not take place with sulphide of copper.

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*Schönbein has proposed ozone as an oxidiser of arsenical stains. The substance containing the stain, together with a piece of moist phosphorus, is placed under a shade, and left there for some time; the oxidisation product is, of course, coloured yellow by SH_2 if it is arsenious acid, orange if antimony. The vapour of iodine colours metallic arsenic pale yellow, and later a brownish hue; on exposure to the air it loses its colour. Iodine, on the other hand, gives with antimony a carmelite brown, changing to orange.

An arsenical ring may be also treated as follows :—Precipitated zinc sulphide is made into a paste with a little water, and introduced into the end of the tube; the same end is then plunged into dilute sulphuric acid, and the ring heated, when the arsenical sulphide will be produced.

† *Journ. f. Pract. Chemie*, 13, 68, p. 168.

The arsenical stain, when heated in the tube or cell, gives a crystalline sublimate of arsenious acid; while the antimonial stain is much bluer, and gives no crystalline sublimate. Moreover, the antimony can readily be converted into antimoniate of potash, by warming the copper in water made alkaline by potash, and first reddened by potassic permanganate; heated in this way it, of course, dissolves; and on filtering off the manganese, acidifying with HCl, and testing with SH_2, the orange sulphide is obtained.

Some of the foregoing tests may be applied if there is sufficient material, but if not, it is better at once to pass to Bloxam's method (p. 533), which will give positive results without interfering with subsequent tests.

Arsenic in Organic Matters.—Orfila and the older school of chemists took the greatest care in searching for arsenic to destroy the last trace of organic matter. Orfila's practice was to chop up the substance and make it into a paste with 400 to 700 grms. of water; to this ·010 grm. KHO in alcohol were added, and ·020 grm. of potassic nitrate. The substances were heated up to from 80° to 90° for some time, until they were pretty well dissolved; the organic matter was then burnt off in a Hessian crucible heated to redness, on which small quantities of the matters were placed at a time. When the whole had thus been submitted to red heat, the melted mass was run into an almost red-hot porcelain basin, and allowed to cool. Afterwards, it was again heated with concentrated sulphuric acid, until all nitric and nitrous fumes were dissipated; on dissolving and filtering in water, the liquid was introduced into a Marsh's apparatus. Orfila never seems to have failed in detecting arsenic by this process. For an organ like the liver, he considered that 100 grms. of potash and 86 of strong sulphuric acid were necessary in order to destroy the organic matters.

The liability of the various reagents used to impurity, and the probability of loss in these operations have tended to discredit destruction of the organic matter by a red heat, and chemists generally have preferred to oxidise animal matters by a moist process. The organic substance is divided finely and digested with dilute hydrochloric acid, and from time to time crystals of potassic chlorate are thrown in until all the fluid is very thin and capable of passing through a filter. The filtrate must now be submitted to the prolonged action of sulphuretted hydrogen * and the sulphide of arsenic separated from free sulphur by dissolving in sodic sulphide. After filtering, the arsenic sulphide may be again thrown down by the addition of hydrochloric acid, collected on a filter, and still further purified by solution in ammonic carbonate; once more precipitated by hydrochloric acid, and lastly identified by conversion into magnesia pyro-arseniate (see p. 539). The above process is a very general and safe way of detecting arsenic in almost any organic tissue, but some substances may be more conveniently treated by special processes. Resinous matters, for example, may be first extracted by alcohol, and the residue dissolved in dilute hydrochloric acid, and boiled in a flask which is connected to a vertical condenser. The alcoholic solution may be tested by electrolysis to see whether any arsenic has been dissolved; if this is the case, the resin may be precipitated by water and filtered off.

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* The SH_2 should be washed by passing it through two or more washing bottles supplied with warm dilute HCl—a few samples of sulphide of iron give off an arseniferous gas, so that this precaution is necessary.

From ordinary pills, quack extracts, and similar preparations, drying, powdering, and exhaustion with boiling dilute HCl, will remove the whole of the arsenic, if in a soluble state; if not, *aqua regia* must be employed.

Oils and matters consisting almost entirely of fat, suspected of containing arsenic, are gently heated, and allowed to deposit any insoluble matter they may contain; the oil is then decanted, and, if necessary, filtered from any deposit; saponified by alcoholic potash, the soap decomposed by HCl, the fatty acids separated, and the arsenic looked for both in the first deposit and in the solution, now fairly free from fat, and easy to treat.

In searching for arsenic in the fluids or tissues of the body, the analyst is generally at the mercy of the pathologist, and sometimes the work of the chemist leads to a negative result, solely from not having the proper organ sent to him.*

Brodie long ago stated that when arsenious acid had been given in solution, to any animal capable of vomiting, no arsenic could be detected in the stomach; this statement is too absolute, but in the majority of cases true.

In all cases the chemist should have portions of the brain, spinal cord, liver, kidneys, lungs, and muscular tissue, as well as the stomach and its contents.

According to the experiments of Scolosuboff,† arsenic is generally greatest in the marrow, then in the brain, next in the liver, and least in the muscles, and the following may be taken as a fairly accurate statement of the relative proportion in which arsenic is likely to be found in the body, 100 grms. being taken of each :—

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* For example, in cases of poisoning by external application, more than once merely the empty stomach and a piece of intestine have been forwarded to the writer.

† *Bull. Soc. Chim.* [2], xxiv., p. 124.

Muscles,	1
Liver,	10·8
Brain,	36·5
Spinal Marrow,	37·3

But Ludwig's[*] experiments and conclusions are entirely opposed to this, since both in acute and chronic cases he found as follows (per cent. As_2O_3) :—

Brain,	·0002
Liver,	·001
Kidney,	·0004
Muscle,	·00025

So that he detected in the liver five times more than in the brain. M. P. Hamberg has also confirmed the fact, that more is found in the liver and kidneys than in the nervous tissues.

With regard to the preliminary treatment of the stomach and fluids submitted to the analyst, the careful noting of appearances, the decantation, washing, and examination[†] (microscopical and chemical) of any deposit, are precautions so obviously dictated by common sense, that they need only be alluded to in passing. Of some considerable moment is the question which may be put to the analyst in court, in reference to the possible entrance of arsenic into the living body, by accidental and, so to speak, *subtle* means. Such are the inhaling of the fumes from the burning of arsenical candles,[‡] and of emanations from papers (see p. 505),[§] as well as the possible entrance of arsenic into the body after death from various sources, such as arsenical earth, &c.[‖]

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[*] *Ueber die Verhaltung des Arsens im thierischen Organismus nach Einverleibung von Arseniger Säure. Med. Jahrbuch*, 1880.

[†] From some observations of Fresenius in a recent number of the *Zeitschrift f. Anal. Chem.*, it would seem necessary to test all glass vessels used; for it is difficult at present to purchase arsenic-free glass.

[‡] See a case of poisoning (non-fatal) of a lady by the use of arsenical candles, *Med. Times and Gazette*, vol. iii., 1876, p. 367.

[§] To solve this question, it has been at times considered necessary to analyse an extraordinary number of things. In the "affaire Danval" (*Journ. de Hygiène*, 2e ser., No. 108, July, 1878), more than sixty different articles, comprising drugs, drinks, perfumes, bed-curtains, wall-paper, and other matters, were submitted to the experts.

[‖] The following important case is related by Sonnenschein:

Nicholas Nobel and his wife, Jerome, were buried two metres from each other in the churchyard at Spinal, the earth of which notoriously contained arsenic. A suspicion of poisoning arose. The bodies were exhumed, and arsenic

The arguments which are likely to be used in favour of a corpse having become arsenical may be gathered from a case related by Sonnenschein :—Certain bodies were exhumed in two churchyards; the evidence went to show that they had been poisoned by arsenic, and this substance was actually found in the bodies, while at the same time it was discovered to exist also in traces in the earth of the churchyard. The theory for the defence was, that although the arsenic in the earth was in an insoluble state, yet that it might combine with lime as an arsenite of lime; this arsenite would become soluble by the action of carbonic acid set free by vegetation, and filter down to the corpse. Sonnenschein suspended a quantity of this earth in water, and passed CO_2 through it for twelve hours; on filtering, the liquid gave no evidence of arsenic. A similar result was obtained when an artificial mixture of 1 grm. of arsenious acid and 1 pound of earth were submitted to the same process.

The fact would appear to stand thus: oxide of iron in ordinary earth retains arsenic, and requires treatment with a concentrated acid to dissolve it. It therefore follows that, if a defence of arsenical earth is likely to be set up, and the analyst finds that by mere extraction of the tissues by *water* he can detect arsenic, the defence is in all probability unsound. The expert should, of course, deal with this question on its merits, and without prejudice. According to Eulenberg,* in arsenical earth—if after having been crushed and washed, it lies for some time exposed to the disintegrating action of the air—soluble arsenical salts are formed, which may find their way into brooks and supplies of drinking water. We may infer that it is hardly probable (except under very peculiar circumstances) for a corpse to be contaminated internally with an estimable quantity of arsenic from the traces of arsenic met with in a few churchyards.

It occasionally happens that an exhumation is ordered a very long time after death, when no organs or parts (save the bones) are to be distinguished. In the case of a man long dead, the widow confessing that she had administered poison, the bones were analysed by Sonnenschein, and a small quantity of arsenic found. Conièrbe and Orfila have both asserted that arsenic is a normal constituent of the bones—a statement

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was found in the stomach and intestines of Nobel, but not the slightest trace in the corpse of the wife. The remains of the bodies were reinterred, and after six months, on a fresh suspicion of poisoning arising, again exhumed. The corpse of the woman had been put naked in the moist earth during a heavy shower, but this time also no arsenic was detected in it.

* *Gewerbe Hygiène*, p. 284.

which has been repeatedly disproved. Sonnenschein relates :—* "I procured from a churchyard of this place (Berlin), the remnants of the body of a person killed twenty-five years previously, and investigated several others in a similar way, without finding the least trace of arsenic. Similar experiments in great number were repeated in my laboratory, but in no case was arsenic recognised." The opinion of the expert, should he find arsenic in the bones, must be formed from the amount discovered, and other circumstances.

Imbibition of Arsenic by Dead Tissues.—In a case which occurred in the Western States of America, there was good reason for believing that arsenic had been introduced into the corpse of a man *after* his decease. With regard to the imbibition of arsenic thus introduced, Orfila† says : "I have often introduced into the stomach (as well as the rectum) of the corpses of men and dogs 2 to 3 grms. of arsenious acid, dissolved in from 400 to 500 grms. of water, and have examined the different viscera at the end of eight, ten, or twenty days. Constantly I have recognised the effects of cadaveric imbibition. Sections of the liver or other organs which touch the digestive canal, carefully cut and analysed, furnished arsenic, which could not be obtained sensibly (or not at all) from sections which had not been in contact with this canal. If the corpse remained long on the back after arsenious acid had been introduced into the stomach, I could obtain this metal from the left half of the diaphragm and from the inferior lobe of the left lung, whilst I did not obtain it from other portions of the diaphragm nor from the right lung." Dr. Reece has also made some experiments on the imbibition of arsenic after death. He injected solutions of arsenious acid into the stomach of various warm-blooded animals, and found at various periods arsenic, not alone in the intestinal canal, but also in the spleen, liver, and kidneys.

Analysis of Wall-paper for Arsenic.—The separation of arsenic from paper is extremely easy, and admits of great variety of manipulation. A very quick special method is as follows :—The paper is saturated with chlorate of potash solution, dried, set on fire in a suitable plate, and instantly covered with a bell-glass. The ash is collected, pulverised and exhausted with cold water, which has previously thoroughly cleansed the plate and bell-glass ; the arsenic in combination with the potash is dissolved, whilst oxides of chromium, copper, aluminium, tin, and lead, remain in the insoluble portion.‡

On investigating the air of a room or chamber suspected of being impregnated with arsenic, it is important to know whether it is caused by arsenical dust or by AsH_3. In the case of a child dying with symptoms of arsenical poisoning in a room papered with a pigment containing Scheele's green, Sonnenschein* placed a perfectly clean table in the room, which was kept closed for eight days. At the end of that time he examined the dust of the table by the microscope and chemically; the former revealed green particles, the latter arsenic. It would, however, appear both a more rapid and convenient method to draw a large number of litres of air through a solution of nitrate of silver, and filter the air through cotton wool; at the termination of the experiment examining the wool for arsenical dust, and the nitrate of silver for arsenious acid. A convenient aspirator for such a purpose is an ordinary ale cask, filled with water; a bit of brass tubing is screwed through a hole in the bung, and connected with the absorption apparatus, the water being allowed to trickle away slowly through a tap placed in the usual position.†

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* *Gerichtl. Chem.*, p. 212.

† *Op. cit.*, t. i., p. 309.

‡ Kapferschlaeger : *Rev. Universelle des Mines*, 1876.

Estimation of Arsenic.—Most of the methods for the quantitative determination of arsenic are also excellent tests for its presence. It may be regarded, indeed, as an axiom in legal chemistry, that the precise amount of every substance detected, if it can be weighed or estimated by any process whatever, should be accurately stated. Indefinite expressions, such as "a small quantity was found," "traces were detected," &c., are most objectionable. The more perfect of the methods of evolving arsenic can be made quantitative. For example, the galvanic process introduced by Bloxam may be utilised as follows:—A fractional part of the arsenical solution is taken for the experiment; the bottom of a narrow-necked bottle of about 100 cc. capacity is removed, and replaced by a piece of vegetable parchment. The neck of the bottle carries a cork, which is pierced by (1) a platinum wire, which is attached to a platinum electrode; (2) a short tube, bent at right angles, and connected by piping with a longer tube which has also a rectangular bend, and dips into a solution of silver nitrate; (3) an ordinary funnel-tube, reaching nearly to the bottom. The bottle is placed in a beaker of such a size as to leave a small interval between the two, and the whole apparatus stands in a large vessel of cold water. Dilute sulphuric acid is now put into the bottle, and also into the beaker, so that the fluid reaches exactly the same level in each. The positive platinum electrode of a battery of six of Grove's cells, or other efficient combination, is immersed in the liquid outside the bottle, connection with the negative plate is established, and hydrogen very soon comes off, and passes over into the nitrate of silver solution. When all the air is expelled, a portion of the rectangular tube is heated to redness, and if there is no stain nor any reduction of the silver, the acid is pure. If the gas is passed for a long time into the silver solution, the silver will be reduced to some extent by the hydrogen, although arsenic-free ;* so that it is better to rely upon the metallic ring or stain, which is certain to be formed on heating a portion of the tube red-hot, and keeping it at that temperature for *at least ten minutes*. The liquid is then passed through the funnel in successive portions ; if arsenic is present, there will be a decided metallic ring on heating the tube as before, and if antimony is present, there will also be a stain ; the distinctions between these stains have been described at p. 499.

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* *Handbuch der Gerichtl. Chem.*, p. 153.

† The investigation of emanation supposed to be arsenical from manufactories, &c., must be conducted on the same principles. It would appear that arsenical fumes are evolved in the action of impure sulphuric acid on coprolites, a fact not before observed.—"On the Presence of Arsenic in the Vapour of Bone Manure," by J. Adams.

The tube is kept red-hot until the stain is very distinct ; then the source of heat is removed, and the gas allowed to bubble through the argentic nitrate solution, which it decomposes, as before detailed (p. 471). This process is continued until, on placing the delivery tube in a sample of clear nitrate of silver solution, there is no darkening of colour. In certain cases this may take a long time, but the apparatus, once set to work, requires little superintendence. At the conclusion, the whole of the arsenic is separated,—part is in the silver solution as arsenious acid, part in the tube as a ring of metallic arsenic. The portion of the tube containing the metallic arsenic should be cut off with a file and weighed, the arsenic then removed and re-weighed; the loss is the metal approximately. Or, the weight of the film may be estimated by having a set of similar deposits of known weight or quantities, in tubes exactly corresponding to those used in the analysis, and comparing or matching them.

The arsenious acid in the nitrate of silver may be dealt with in several ways. The equation given p. 471 shows clearly that pure arsine passed into nitrate of silver solution, decomposes it in such a manner that, if either the silver deposited or the free acid is estimated, the quantity of arsenic can from such data be deduced. In operating on organic liquids, ammonia and other products may be given off, rendering either of the indirect processes inadvisable. A very convenient method, applicable in many cases, is to throw out the silver by hydrochloric acid, alkalise the filtrate by bicarbonate of soda, and titrate with iodine solution. The latter is made by dissolving exactly 12·7 grms. of pure dry iodine, by the aid of 18 grms. of potassic iodide in one litre of water, observing that the solution must take place in the cold, without the application of heat. The principle of the titration is, that arsenious acid, in the presence of water and free alkali, is converted into arsenic acid.

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* Nitrate of silver solution is reduced by H_2, CH_4, PH_3, and SbH_3 ; hence it is absolutely necessary in any qualitative examination to prove that arsenious acid has actually been produced in the silver solution.

$$As_2O_3+4I+2Na_2O=As_2O_5+4NaI.$$

The end of the reaction is known by adding a little starch-paste to the solution; as soon as a blue colour appears, the process is finished.

Another convenient way by which (in very dilute solutions of arsenious acid) the arsenic may be determined, is a colorimetric method, which depends on the fact that sulphuretted hydrogen, when arsenious acid is present in small quantity, produces no precipitate at first, but a yellow colour, proportionate to the amount of arsenic present. The silver solution containing arsenious acid is freed from silver by hydrochloric acid; a measured quantity of saturated SH_2 water is added to a fractional and, if necessary, diluted portion, in a Nessler cylinder or colorimetric apparatus, and the colour produced exactly imitated, by the aid of a dilute solution of arsenious acid added from a burette to a similar quantity of SH_2 water in another cylinder, the fluid being acidified with HCl.

Destruction of the Organic Matter by Nitric Acid, and Subsequent Reduction of the Arsenic Acid to Arsine (Arseniuretted Hydrogen), and final Estimation as Metallic Arsenic.—This process, which is essentially a combination of several, has been much improved in its details recently by R. H. Chittenden and H. H. Donaldson.* 100 grms. of the suspected matters cut up into small pieces, are heated in a porcelain dish of suitable size, stirred by means of a glass rod with 23 cc. of pure concentrated nitric acid, and heated up to from 150° to 160°. When the matters assume a yellow or orange colour, the bath is removed from the source of heat, and 3 cc. of pure concentrated sulphuric acid added, and the mixture stirred, when the mass becomes brown, swells up, and evolves dense nitrous and other fumes. The vessel is again heated to 180°, and while hot 8 cc. of pure concentrated nitric acid are added, drop by drop, with continual stirring. After this addition, it is heated to 200° for fifteen minutes, and the result on cooling is a hard carbonaceous residue wholly free from nitric acid. The arsenic is in this way oxidised into arsenic acid, which is easily soluble in water. The contents of the dish are, therefore, perfectly extracted by boiling water; the aqueous extract filtered and evaporated to dryness. The next process is to obtain the arsenic in a metallic state:—

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* *American Chem. Journ.*, vol. ii., No. 4; *Chem. News*, Jan. 1881, p. 21.

The flask, a Bunsen's wash-bottle of 200 cc. capacity, is provided with a small separating funnel of 65 cc. capacity with glass stop-cock. This is a very material aid to the obtaining of a slow and even evolution of gas, an important desideratum when all loss is to be avoided; for with only a funnel tube, every time a small portion of fluid is added, a sudden rush of gas takes place, with probably a small but still more or less appreciable loss. But the separating funnel, filled with the acid mixture, can be so arranged as to give a constant and regular supply of fluid at the rate of two or three drops per minute, more or less. The gas generated is dried by a calcic chloride tube, and then passes through a tube of hard glass, heated to a red heat by a miniature furnace of three Bunsen lamps with spread burners, so that a continuous flame of 6 inches is obtained, and with a proper length of cooled tube not a trace of arsenic passes by. The glass tube where heated is wound with a strip of wire gauze, both ends being supported upon the edges of the lamp frame, so that the tube does not sink down when heated. The small furnace is provided with two appropriate side pieces of sheet metal, so that a steady flame is always obtained. When the quantity of arsenic is very small, the tube is naturally so placed that the mirror so deposited in the narrow portion; but when the arsenic is present to the extent of 0·005 grm., the tube should be 6 mm. in inner diameter, and so arranged that fully 2 inches of this large tube are between the flame and the narrow portion. When the quantity of arsenic is less, the tube can naturally be smaller.

Acids of different strengths are made as follows:—

Acid No. 1.	Acid No. 2.
545 cc. pure conc. H_2SO_4.	109 cc. pure conc. H_2SO_4.
5000 cc. H_2O.	1640 cc. Acid No. 1.
Acid No. 3.	**Acid No. 4.**
218 cc. pure conc. H_2SO_4	530 cc. pure conc. H_2SO_4.
1640 cc. Acid No. 1.	1248 cc. H_4O.

26 to 35 grms. of granulated zinc, previously alloyed with a small quantity of platinum, are placed in the generator, and everything being in position, the apparatus is filled with hydrogen by the use of a small quantity of acid No. 2. After a sufficient time has elapsed, the gas is lighted at the jet, and the glass tube heated to a bright redness.

The arsenical solution in concentrated form is mixed with 45 cc. of acid No. 2, and the mixture passed into the separating funnel, from which it is allowed to flow into the generator at such a rate that the entire fluid is introduced in one hour or one and a half; 40 cc. of acid No. 3 are then added and allowed to flow slowly into the generator, and lastly, 45 cc. of acid No. 4. The amount of time required will vary with the amount of arsenic: 2 to 3 mgrms. of arsenic will require about two to three hours for the entire decomposition, while 4 to 5 mgrms. will need perhaps three to four hours. Where the amount of arsenic is small, only 25 grms. of zinc are needed, and but 45 cc. of acid No. 2, 30 cc. of acid No. 3, and 30 cc. of acid No. 4; but when 4 to 5 mgrms. of arsenic are present, it is better to take the first mentioned quantities of zinc and acids.

The arsenic being thus collected as a large or small mirror of metal, the tube is cut at a safe distance from the mirror, so that a tube of perhaps 2 to 6 grms. weight is obtained. This is carefully weighed, and then the arsenic removed by simple heating; or, if the arsenic is to be saved (as in a toxicological case), dissolved out with strong nitric acid. The tube is then cleaned, dried, and again weighed, the difference giving the weight of metallic arsenic, from which by a simple calculation the amount of arsenious oxide can be obtained. Some test results are given as follows; they were obtained by introducing definite quantities of arsenious oxide in the form of a solution mixed with 45 cc. of No. 2 acid, &c :—

Quantity of Arsenic introduced.	Wt. of Metallic Arsenic found.	Theoretical Wt. of Metallic Arsenic.
0·005 grm. As_2O_3	0·00373	0·00378
0·005 " "	0·00370	0·00378
0·004 " "	0·00300	0·00303
0·002 " "	0·00151	0·00151

The process is, on the whole, both convenient and accurate, and is highly to be commended.

Evolution of Arsine by Means of Sodium Amalgam.—The method has been proposed by Dr. E. Davy,* and is simply the evolution of nascent hydrogen by sodium amalgam. In the original paper it is suggested as a qualitative test only, and paper soaked in argentic nitrate solution is used as an indicator. It is, however, obvious that the arsenic evolved may be absorbed by argentic nitrate solution, or arsenic deposited as a metallic coating in the tube. A sodium amalgam is prepared by adding 1 part of sodium to 10 parts of mercury; if any quantity of this amalgam is required, the sodium may be melted, under paraffin, and poured in a thin stream on the mercury,† which becomes solid sooner than the paraffin, and the latter may be poured off, finally cleansing the amalgam by petroleum ether. This amalgam will contain no arsenic;

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* *Chem. News*, vol. xxxiii., p. 58.

† *Ibid*, vol. xxxiii., p. 94.

but in a medico-legal investigation it should be nevertheless tested, by evolving hydrogen from water with it, and passing the gas for an hour through argentic nitrate solution. A little silver may be precipitated, giving the solution a slightly smoky colour ; but on freeing the solution from silver by HCl, no arsenic should be detected by hydric sulphide or other tests.

The quantitative analysis by Davy's test is made by placing in a flask a fractional part of the liquid to be examined, adding a few pieces of the amalgam, and conducting the evolved gas into a 4 per cent. argentic nitrate solution. The flask may be conveniently fitted up with an india-rubber cork pierced by two tubes, the one a thistle funnel-tube, reaching nearly to the bottom, the other commencing at the lower end of the cork, and leading in the usual way into the silver solution. When bubbles cease to come off, heat should be applied, and the last trace of arsine driven over by boiling. After boiling, the liquid should be cooled, some fresh amalgam added, and the process repeated until no arsine is evolved. In personal experiments upon this method (using solutions of arsenious acid in beer, wine, spirits, urine, &c.), the writer has found it accurate, although often taking considerable time.

Precipitation as Tersulphide.—Despite the advantages of some of the processes described, which are (to a certain extent) new, easy, and accurate, not a few chemists still prefer the old method of precipitation with hydric sulphide SH_2, because, although tedious, it has stood the test of experience. If this be used, it is well in most cases to pass sulphurous anhydride through the liquid until it smells strongly of the gas, for by this means any arsenic acid present is reduced, the sulphurous anhydride is quickly got rid of by a current of carbonic anhydride, and then the liquid is saturated with hydric sulphide. In the ordinary way, much time is often wasted in saturating the liquid with this gas. Those, however, who have large laboratories, and daily employ hydric sulphide, possess (or should possess) a water saturated with the gas under pressure ; such a liquid, added in equal volume to an arsenical solution, is able to convert the whole of the arsenic into sulphide in a very few minutes. Those who do not possess this hydric sulphide water can saturate in an hour the liquid to be tested, by passing the gas in under pressure. A convenient method is to evolve SH_2 from sulphide of antimony and ClH ; the gas passes first into a wash-bottle, and then into a strong flask containing the solution under trial. This flask is furnished with a safety-valve, proportioned to the strength of the apparatus ; the two tubes dipping into the wash-bottle and the last flask are provided with Bunsen's valves, which only allow the gas to pass in one direction. The hydric sulphide is then driven over by heat, and when sufficient gas has in this way passed into the liquid, the flame is withdrawn, and the apparatus allowed to stand for some hours, the valves preventing any backward flow of the liquid or gas. When the precipitate has settled to the bottom, the supernatant fluid is carefully passed through a filter, and the precipitate washed by decantation in the flask, without transference to the filter, if it can be avoided.

The sulphide thus obtained is the trisulphide of arsenic, mixed with sulphur, and, in most medico-legal inquiries, contaminated by organic matter. It is, therefore, too impure to be directly weighed, and there are several methods of purification open to the analyst.

(*a.*) *Solution in Ammonia and Estimation by Iodine.**—The filter is pierced, and the sulphide washed into a flask by ammonia water (which need not be concentrated), and dissolved by warming, filtered from any insoluble matter, and estimated by iodine and starch.

(*b.*) *Drying the Purified Precipitate at a high temperature, and then directly weighing.*†—The sulphide is dissolved, as before, in ammonia, filtered, and evaporated to dryness in a porcelain dish, which is placed with its contents on a sand-bath, and heated carefully. With attention it is easy to evaporate off in this way any free sulphur, ‡ and to carbonise the traces of organic matter, without any volatilisation of the sulphide of arsenic. The black mass is once more dissolved in ammonia, filtered, and the filtrate evaporated in a tared porcelain dish to dryness, and finally weighed as sulphide of arsenic.

(*c.*) *Oxidation of the Sulphide and Precipitation as Ammonia Magnesian Arseniate, or Magnesia Pyro-Arseniate.*—The tersulphide, as before, is dissolved in ammonia (not omitting the filter paper, which should be soaked in this reagent), the solution filtered, and evaporated to dryness. The dry residue is now oxidised by fuming nitric acid, taking care to protect the dish with a large watch-glass (or other cover) during the first violent action; the dish is then heated in the water-bath until all the sulphur has disappeared, and only a small bulk of the liquid remains; it is then diluted and precipitated by "magnesia mixture." § The fluid must stand for several hours, and, if the arsenic is

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* P. Champion and H. Pellet, *Bull. Soc. Chim.* [2], xxvi., pp. 541–544.

† F. Mohr, *Chem. Toxicologie*, p. 56.

‡ Ammonia always dissolves some free sulphur.

§ Magnesia Mixture :—

Sulphate of magnesia,	1
Chloride of ammonium,	1
Solution of ammonia,	4
Water,	8

dissolve; then allow to stand for several days; finally filter, and keep for use.

to be determined as the usual ammoniacal salt, it must be passed through a weighed filter, and washed with a little ammoniacal water (1:3). The solubility of the precipitate is considerable, and for every 16 cc. of the filtrate (not the washings) 1 mgrm. must be allowed. The precipitate dried at 100°, $2(NH_4MgAsO_4)H_2O$ represents 39·47 per cent. metallic arsenic.

The solubility of the magnesium arseniate itself, and the general dislike which chemists have to weighing in such hygroscopic material as a filter, are, perhaps, the main reasons for the variation of this old method, which has lately come into notice. Rose proposed some time ago the conversion of the double salt into the pyro-arseniate—a method condemned by Fresenius and Parnell, but examined and pronounced a practicable and accurate process by Remol, Raunnelsberg, Thorpe, Fuller, Wittstein, Emerson, Macivor, Wood, and Brauner. The modification of Rose's process, recommended by Wood,* and still further improved by Brauner,† may be accepted.

The precipitation is affected by magnesia mixture, with the addition of half its bulk of alcohol. The solution is allowed to stand for several hours, until it is possible to decant the clear liquid from the precipitate; the latter is now dissolved in ClH, reprecipitated as before, thrown on a small filter, and washed with a mixture of one volume of ammonia, two volumes of alcohol, and three of water.

The precipitate is now dried, and transferred as completely as possible from the filter into a small porcelain crucible, included in a larger one made of platinum, moistened with nitric acid, covered and heated at first gently, lastly to a bright redness; the filter is then treated similarly, and the crucible with its contents weighed. Pyro-arseniate of arsenic ($Mg_2As_2O_7$) contains 48·29 per cent. of metallic arsenic.

(*d.*) *Conversion of the Trisulphide cf Arsenic into the Arsenomolybdate of Ammonia.*—The purified sulphide is oxidised by nitric acid, the acid solution is rendered alkaline by ammonia, and then precipitated by a molybdenum solution made as follows: 100 grms. of molybdic acid are dissolved in 150 cc. of ordinary ammonia and 80 of water; this solution is poured drop by drop into 500 cc. of pure nitric acid and 300 cc. of water; it is allowed to settle, and, if necessary, filtered. The molybdic solution must be mixed in excess with the liquid under treatment, the temperature raised to 70° or 80°, and nitric acid added in access until a yellow coloration appears; the liquid is then passed through a tared filter, and dried at 100°. It contains 5·1 per cent. of arsenic acid [3·3 As.]‡

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* *Zeitschrift für Anal. Chem.*, vol. xiv., p. 356.

† *Ibid*, xvi., pp. 57, 58.

‡ Champion and Pellett, *Bull. Soc. Chim.*, Jan. 7, 1877.

(*e.*) *Conversion of the Sulphide into Metallic Arsenic.*—If there should be any doubt as to the nature of the precipitated substances, the very best way of resolving this doubt is to reduce the sulphide to metal. The original process of Fresenius was to mix the sulphide with carbonate of soda and cyanide of potassium, and place the mixture in the wide part of a tube of hard German glass, drawn out at one end to a capillary fineness. Carbonic anhydride, properly dried, was passed through the tube, and the portion containing the mixture heated to redness; in this way the arsenical sulphide was reduced, and the metal condensed in the capillary portion, where the smallest quantity could be recognised. A more elaborate and accurate process, based on the same principles, has been advocated by Mohr.*

A convenient quantity of carbonate of soda is added to the sulphide, and the whole mixed with a very little water, and gently warmed. The yellow precipitate is very soon dissolved, and then the whole is evaporated carefully, until it is in a granular, somewhat moist, adhesive state. It is now transferred to a glass tube, open at top and bottom, but the top widened into a funnel; this tube is firmly held perpendicularly on a glass plate, and the prepared sulphide hammered into a compact cylinder by the aid of a glass rod, which just fits the tube. The cylinder is now dried over a flame, until no more moisture is to be detected, and then transferred into a glass tube four or five inches long, and with one end drawn to a point (the weight of this tube should be first accurately taken). The tube is connected with the following series:—(1) A chloride of calcium tube; (2) a small bottle containing nitrate of silver; (3) a hydrogen-generating bottle containing zinc and sulphuric acid. The hydrogen goes through the argentic nitrate solution, leaving behind any sulphur and arsenic it may contain; it is then dried by chloride of calcium, and streams in a pure dry state over the cylinder of prepared sulphide (no error with regard to impurities in the gas is likely to occur; but in rigid inquiries it is advisable to heat a portion of the tube, previous to the insertion of the cylinder, for some time, in order to *prove* the absence of any external arsenical source); when it is certain that pure hydrogen, unmixed with air, is being evolved, the portion of the tube in which the cylinder rests is heated slowly to redness, and the metallic arsenic sublimes at a little distance from the source of heat. Loss is inevitable if the tube is too short, or the stream of hydrogen too powerful.

The tube after the operation is divided, the portion soiled by the soda thoroughly cleansed, and then both parts weighed; the difference between the weight of the empty tube and the tube+arsenic gives the metallic arsenic. This is the process as recommended by Mohr; it may,

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Mohr's *Toxicologie*, p. 57

however, be pointed out that the glass tube itself loses weight when any portion of it is kept red-hot for some little time; and, therefore, unless the crust is required in the original tube, it is better to divide it, carefully weigh the arsenical portion, remove the crust, and then reweigh. The method is nearly but not perfectly accurate; for if the white alkaline residue be examined, arsenic will be detected in it, the reason being that the arsenical sulphide generally contains penta-sulphide of arsenic as well as free sulphur. Now the pentasulphide does not give up metallic arsenic when treated as before detailed; nor, indeed, does the trisulphide, if mixed with much sulphur, yield an arsenical crust. It is, therefore, of great moment to free the precipitate as much as possible from sulphur, before attempting the reduction.

The development of a reducing gas from a special and somewhat complicated apparatus is not absolutely necessary. The whole process of reduction, from beginning to end, may take place in a single tube by any of the following processes:—(1) The sulphide is mixed with oxalate of soda (a salt which contains no water of crystallisation), and the dry mixture is transferred to a suitable tube, sealed at one end. An arsenical mirror is readily obtained, and, if the heat is continued long enough, no arsenic remains behind—an excellent and easy method, in which the reducing gas is carbonic oxide, in an atmosphere of carbonic anhydride. (2) The sulphide is oxidised by *aqua regia*, and the solution evaporated to complete dryness. The residue is then dissolved in a few drops of water, with the addition of some largish grains of good wood charcoal (which absorb most of the solution), and the whole carefully dried. The mass is now transferred to a tube closed at one end, a little charcoal added in the form of an upper layer, and heat applied first to this upper layer, so as to replace the air with CO_2, and then to bring the whole tube gradually to redness from above downwards. In this case also the whole of the arsenic sublimes as a metallic mirror.

There are various other modifications, but the above are trustworthy, and quiet sufficient. Brugelmann's method of determining arsenic, elsewhere described, would appear to possess some advantages, and to promise well; but the writer has had no personal experience of it with regard to arsenic.

Conversion of Arsenic into Arsenious Chloride ($AsCl_3$).—This process, first employed by Schneider and Fyfe, and afterwards modified by Taylor, differs from all the preceding, since an attempt is made to separate by one operation volatile metallic chlorides, and to destroy the organic matter, and thus obtain two liquids—one a distillate—tolerably clear and free from solid particles, whilst the mass in the retort retains such metals as copper, and is in every way easy to deal with.

Schneider and Fyfe employed sulphuric acid and common salt; but Taylor recommends hydrochloric acid, which is in every respect preferable. As recommended by Taylor all matters, organic or otherwise, are to be completely desiccated before their introduction into a retort, and on these dried substances sufficient pure hydrochloric acid poured, and the distillation pushed to dryness. Every one is well aware how tedious is the attempt to dry perfectly the organs of the body (such as liver, &c.) at any temperature low enough to ensure against volatilisaton of such a substance as, *e. g.*, calomel. This drying has, therefore, been the great stumbling-block which has prevented the general application of the process. It will be found, however, that drying in the ordinary way is by no means necessary. The writer cuts up the solid organ (such as liver, brain, &c.) with scissors into small pieces, and transfers them to a retort fitted by an air-tight joint to a Liebig condenser; the condenser in its turn being connected with a flask by a tube passing through an india-rubber stopper. Another tube from the same flask is connected with india-rubber piping, which terminates ultimately by an iron tube, in an open fire, furnace chimney, or other place convenient for conveying off the very offensive vapors from the laboratory. The distillation is now carried on to carbonisation; on cooling, a second quantity of hydrochloric acid is added, and the last fraction of the distillate examined for arsenic. If any is found, a third distillation is necessary. At the termination of the operation the retort is washed with water, the solution filtered, and this solution and the distillate are each separately examined for arsenic. If properly performed, however, the second distillation brings over the whole of the arsenical chloride,* and none will be found in the retort. With good management there is no odour, nor is there any loss of substance. In the distillate the arsenic can hardly be in the form of arsenious chloride, but rather arsenious acid and hydrochloric acid; for the chloride easily splits up in the presence of water into these substances. However that may be, it is in a condition to be very easily dealt with. It is, perhaps, best to convert it into the trisulphide. Taylor † recommends evolving arsine in the usual way, and passing the arsine (AsH_3) into solution of silver nitrate, finally estimating it as an arseniate of silver. Objections with regard to the impurity of reagents should be met by blank experiments. Kaiser ‡ has proposed and practiced a modification of this method, which essentially consists in the use of sulphuric acid and sodic chloride (as in Schneider and Fyfe's original process), and in passing the distillate first into a flask containing a crystal or two of potassium chlorate, and thence into an absorption bulb; in the latter most of the arsenic is found in the form of arsenic acid, the chloride having been oxidised in its passage. The apparatus is, however, complicated in this way without a corresponding advantage.[*] Lastly, E. Fischer [†] has shown that it is a considerable advantage to add from 10 to 20 cc. of a saturated solution of ferrous chloride before distilling with HCl. In this way, all the arsenic, whether as arsenic or arsenious acids, is easily converted into chloride.

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* Dragendorff asserts to the contrary; but we may quote the authority of Taylor, who has made several experiments, in which he obtained all the arsenic as chloride. The writer has performed the process many times, each time carefully testing the mass in the retort for arsenic; but the result proved that it had entirely passed over.

† "Principles of Medical Jurisprudence." vol. i., p. 267.

‡ *Zeitschr. f. Anal. Chem.*, xiv., pp. 250-281.

2. ANTIMONY.

Metallic Antimony.—Atomic weight, 120·3 (R. Schneider), 120·14 (Cook[‡]) ; specific gravity, 6·715 ; fusing point about 621° (1150°F.) In the course of analysis, metallic antimony may be seen as a black powder thrown down from solutions ; as a film deposited on copper or platinum; and lastly as a ring on the inside of a tube from the decomposition of stibine. At a bright-red heat it is volatilised slowly, even when hydrogen is passed over it ; chlorine, bromine, and iodine combine with it directly. It may be boiled in concentrated ClH without solution ; but *aqua regia* sulphides of potassium and sodium readily dissolve it. The distinction between thin films of this metal and of arsenic on copper and glass are pointed out at pp. 499 and 500. It is chiefly used in the arts for purposes of alloy, and enters to a small extent into the composition of fireworks (*vide* p. 478).

Antimonious Sulphide.—Sulphide of antimony = 340 ; composition in 100 parts, Sb 71·76, S 28·24. The commercial article known under the name of black antimony, is the native sulphide, freed from silicious matter by fusion, and afterwards pulverised. It is a crystalline metallic-looking powder, of a steel grey colour, and is often much contaminated with iron, lead copper, and arsenic.

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[*] Selmi (*Atti dell. Accademia dei Lincei,* Fasc. ii., 1879), proposed a modification of Schneider's process. The substances are treated with hot, pure sulphuric acid, and at the same time the liquid is traversed by a stream of hydrochloric acid gas. The resulting distillate is tested for arsenic by Marsh's process Selmi states that, operating in this way, he has detected $\frac{1}{400}$ of a mgrm. of As_2O_3 in 100 grms. of animal matter.

[†] *Scheidung u. Bestimmung d. Arsens.* Leibig's *Annalen d. Chemie,* Bd. ccvii., p. 182.

[‡] *Ann. Phys. Chem.,* (2), v., pp. 255-281.

The amorphous sulphide (as obtained by saturating a solution of tartar emetic with SH_2) is an orange-red powder, soluble in potash, ammonic, sodic, and potassic sulphides; and dissolving also in concentrated hydrochloric acid with evolution of SH_2. It is insoluble in water and dilute acid, scarcely dissolves in carbonate of ammonia, and is quite insoluble in potassic bisulphite. If ignited gently in a stream of carbonic acid gas, the weight remains constant. To render it anhydrous a heat of 200° is required.

The recognition of arsenic in the commercial sulphide is most easily effected by placing 2 grms. or more in a suitable retort (with condenser), adding hydrochloric acid, and distilling. The choloride of arsenic passes over before the chloride of antimony; and by not raising the heat too high, very little antimony will come over, even if the distillation be carried almost to dryness. The arsenic is detected in the distillate by the ordinary methods.

Several lamentable accidents have happened recently through mistaking the sulphide of antimony for oxide of manganese, and using it with potassic chlorate for the production of oxygen. The addition of a drop of hydrochloric acid, it is scarcely necessary to say, will distinguish between the two.

Antimony is frequently estimated as sulphide. An amorphous tersulphide of mercury, containing a small admixture of antimonious oxide and sulphide of potassium, is known under the name of *Kermes mineral*, and has lately been employed in the vulcanising of india-rubber. Prepared in this way, the latter may be used for various purposes, and thus become a source of danger. It behooves the analyst, therefore, in searching for antimony, to take special care not to use any india-rubber fittings which might contain the preparation.

A *pentasulphide of antimony* (from the decomposition of Schleppe's salt [$Na_3S_6S_4+9H_2O$], when heated with an acid) is used in calico-printing.

Tartarated Antimony, Tartrate of Potash and Antimony, or Tartar Emetic, is, in a medico-legal sense, the most important of the antimonial salts. Its formula in $KSbC_4H_4O_7H_2O$, and 100 parts, theoretically, should contain 35·2 per cent. of metallic antimony. According to the B.P., 20 grains (1·296 grm.) dissolve without residue in an ounce (28·396 cc.) of water; and the solution gives with sulphretted hydrogen an orange precipitate, which, when weighed and dried at 100° (212°F,), weighs 9·91 grains (·641 grm.). Tartar emetic occurs in commerce in colourless, transparent, rhombic, octahedral crystals, slightly efflorescing in dry air.

A crystal, placed in the subliming cell (p. 229), decrepitates at 193·3° (380°F), sublimes at 248·8° (480°F.) very slowly and scantily, and chars at a still higher temperature, 287·7° (550°F.). On evaporating a few drops of a solution of tartar emetic, and examining the residue by the microscope, the crystals are either tetrahedra, cubes or branched figures. 100 parts of cold water dissolve 5 of tartar emetic, whilst the same quantity of boiling water dissolves ten times as much—viz., 50. The watery solution decomposes readily with the formation of algæ; it gives no precipitate with ferrocyanide of potassium, chloride of barium, or nitrate of silver, unless concentrated.

Metantimonic Acid, so familiar to the practical chemist from its insoluble sodium salt, is technically applied in the painting of glass, porcelain, and enamels; and in an impure condition, as antimony ash, to the glazing of earthenware.

Pharmaceutical, Veterinary, and Quack Preparations of Antimony.[*]

(1.) *Pharmaceutical Preparations*:—

Oxide of Antimony (Sb_2O_3) is a white powder fusible at a low red heat, and soluble without effervescence in hydrochloric acid, the solution responding to the ordinary tests for antimony. Arsenic may be present in it as an impurity; the readiest means of detection is to throw small portions at a time on glowing charcoal, when very small quantities of arsenic will, under such conditions, emit the peculiar odour. Carbonate of lime appears also to have been found in the oxide of commerce.

Antimonial Powder is composed of one part of oxide of antimony and two parts of phosphate of lime; in other words, it ought to give 33·3 per cent. of Sb_2O_3.

Tartar Emetic itself has been already described. The preparations used in medicine are—

The Wine of Antimony (*Vinum antimoniale*), which is a solution of tartar emetic in sherry-wine, and should contain 10 grains of the salt in each ounce of the wine (2·27 grms. in 100 cc.).

Antimony Ointment (*Unguentum antimonii tartarati*) is a mechanical mixture of tartar emetic and lard, or simple ointment;[†] strength, 20 per cent. There is no recorded case of conviction for the adulteration of tartar emetic; cream of tartar is the only probable addition. In such a case the mixture is less soluble than tartar emetic itself, and on adding a small quantity of carbonate of soda to a boiling solution of the suspected salt, the precipitated oxide, at first thrown down, becomes redissolved.

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[*] The history of antimony as a drug is curious. Its use was prohibited in France in 1566, because it was considered poisonous, one Besnier being actually expelled from the faculty for transgressing the law on this point. The edict was repealed in 1650; but in 1668 there was a fresh enactment, confining its use to the doctors of the faculty.

[†] Simple ointment is composed of white wax 2, lard 3, almond oil 3 parts.

Solution of Chloride of Antimony is a solution of the terchloride in hydrochloric acid; it is a heavy liquid of a yellowish red colour, powerfully escharotic; its specific gravity is 1·47; on dilution with water, the whitish-yellow oxychloride of antimony is precipitated. One drachm (3·549 cc.) mixed with 4 ounces (112 cc.) of a solution of tartaric acid (·25 : 4), gives a precipitate with SH_2, which weighs *at least* 22 grains (1·425 grm.). This liquid is used on very rare occasions as an outward application by medical men; farriers sometimes employ it in the foot-rot of sheep.

Sulphurated Antimony (*Antimonium sulphuratum*) is a mixture of sulphide of antimony, Sb_2S_3, with a small and variable amount of oxide, Sb_2O_3. The P.B. states that 60 grains (3·888 grms.) dissolved in ClH, and poured into water, should give a white precipitate of oxychloride of antimony, which (properly washed and dried) weighs about 53 grains (3·444 grms.). The officinal compound pill of subchloride of mercury (*Pilala hydrargyri subchloridi composita*) contains 1 grain (·0648 grm.) of sulphurated antimony in every 5 grains (·324 grm.) *i. e.*, 20 per cent.

(2.) *Patent and Quack Pills*:—

Dr. J. Johnson's Pills.—From the formula each pill should contain ·—

	Grains.		Grms.
Compound Extract of Colocynth, .	2·5	—	·162
Calomel, ...	·62	—	·039
Tartar Emetic, ...	·04	—	·002
Oil of Cassia, ...	·12	—	·007
	3·28	—	·210

The oil of cassia can be extracted by petroleum ether; the calomel sublimed and identified by the methods given in the article on "Mercury;" the antimony deposited in the metallic state on platinum or tin; and the colocynth extracted by dissolving in water, acidifying, and shaking up with chloroform. On evaporating the chloroform the residue should taste extremely bitter; dissolved in sulphuric acid it changes to a red colour, and dissolved in Fröhde's reagent to a cherry-red. It should also have the ordinary reactions of a glucoside.

Mitchell's Pills contain in each pill:—

	Grains.		Grms.
Aloes, ...	1·1	—	·070
Rhubarb, ...	1·6	—	·103
Calomel, ...	·16	—	·010
Tartar Emetic, ...	·05	—	·003
	2·91	—	·186

The mineral substances in this are easy of detection by the methods already given; the aloes by the formation of chrysammic acid, and the rhubarb by its microscopical characters.

Dixon's Pills probably contain the following in each pill:—

	Grains.		Grms.
Compound Extract of Colocynth,	2·0	=	·1296
Rhubarb,	1·0	=	·0648
Tartar Emetic,	·06	=	·0038
	3·06	=	·1982

(3.) *Antimonial Medicines, chiefly Veterinary*:—*

Liver of Antimony is a preparation formerly much used by farriers. It is a mixture of antimonious oxide, sulphide of potassium, carbonate of potassium, and undecomposed trisulphide of antimony (and may also contain sulphate of potassium), all in very undetermined proportions. When deprived of the soluble potash salts, it becomes the *washed saffron of antimony* of the old pharmacists. A receipt for a grease-ball, in a modern veterinary work, gives, with liver of antimony, cream of tartar and guiacum as ingredients.

Hind's Sweating-ball is composed of 60 grains (3·888 grms.) of tartar emetic and an equal portion of assafœtida, made up into a ball with liquorice powder and syrup. The assafœtida will be readily detected by the odour, and the antimony by the methods already recommended.

Ethiops of Antimony, very rarely used now, is the mechanical mixture of the sulphides of antimony and mercury—proportions, 3 of the former to 2 of the latter.

The Flowers of Antimony is an impure oxysulphide of antimony, with variable proportions of trioxide and undecomposed trisulphide.

Diaphoretic Antimony (*calcined antimony*) is simply antimoniate of potash.

Glass of Antimony is a mixture of sulphide and oxide of antimony, contaminated with a small quantity of silica and iron.

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* There has long prevailed an idea (the truth of which is doubtful) that antimony given to animals improves their condition; thus, the *Encyclop. Brit.*, 5th ed., Art. "Antimony:"—"A horse that is lean and scrubby, and not to be fatted by any means, will become fat on taking a dose of antimony every morning for two months together. A boar fed for brawn, and having an ounce of antimony given him every morning, will become fat a fortnight sooner than others put into the stye at the same time, and fed in the same manner, but without the antimony." Probably the writer means by the term *antimony* the impure sulphide. To this may be added the undoubted fact, that in Brunswick the breeders of fat geese add a small quantity of antimonious oxide to the food, as a traditional custom.

A quack pill, by name, *Ward's Red Pill,* is said to contain glass of antimony and dragon's blood.

Antimonial compounds used in Pyrotechny:—

Blue fire :—

Antimonious Sulphide,	1
Sulphur,	2
Nitre	6

This composition is used for the blue or Bengal signal-light at sea. Bisulphide of carbon and water are solvents which will easily separate the powder into its three constituents.

Crimson fire :—

Potassic Chlorate,	17·25
Alder or Willow Charcoal,	4· 5
Sulphur,	18·
Nitrate of Strontia,	55.
Antimonious Sulphide,	5. 5

The spectroscope will readily detect strontia and potassium, and the analysis presents no difficulty. In addition to these a very great number of other pyrotechnical preparations contain antimony.

Alloys.—Antimony is much used in alloys. The ancient *Pocula emetica,* or everlasting emetic cups, were made of antimony, and with wine standing in them for a day or two, they acquired emetic properties. The principal antimonial alloys are Britannia and type metal, the composition of which is as follows :

	Tin. per cent.	Copper, per cent.	Antimony, per cent.
Britannia Metal, Best,	92·0	1·8	6·2
Common,	92·1	2·0	5·9
For Castings,	92·9	1·8	5·3
For Lamps,	94·0	1·3	4·7

		Tea Lead. per cent.	Antimony. per cent.	Block Tin. per cent.
Type Metal,	(1.)	75	20	5
	(2.)	70	25	5
Metal for Stereotype,		84·2	13·5	2·3

There is also antimony in brass, concave mirrors, bell-metal, &c.

Pigments.—Casella and Naples yellow are principally composed of the antimoniate of lead.

Antimony Yellow is a mixture of antimoniate of lead with basic chloride of lead.

Dose.—A medicinal dose of a soluble antimonial salt should not exceed 97·2 mgrms. (1½ grain). With circumstances favoring its action, a dose of 129·6 mgrms. (2 grains) has proved fatal ;[*] but this is quite exceptional, and few medical men would consider so small a quantity dangerous for a healthy adult, especially since most posological tables prescribe tartar emetic as an emetic in doses from 64·8 to 194·4 mgrms. (1 to 3 grains). The smallest dose which has killed a child appears to be 48·5 mgrms. (¾ grain).[†] The dose of tartar emetic for horses and cattle is very large, as much as 5·832 grms. (90 grains) being often given to a horse in his gruel three times a day. 3·8 grms. (60 grains) are considered a full, but not an excessive, dose for cattle ; ·38 grm. (6 grains) is used as an emetic for pigs, and half this quantity for dogs.

Effects of Tartar Emetic and of Antimony Oxide on Animals.—Large doses of tartar emetic act on the warm-blooded animals as on man; whether the poison is taken by the mouth, or injected subcutaneously, all animals able to vomit[‡] do so. The heart's action, at first quickened, is afterwards slowed, weakened, and lastly paralysed. This action is noticed in cold as well as in warm-blooded animals. It is to be ascribed to a direct action on the heart ; for if the brain and spinal cord of the frog be destroyed—or even if a solution of the salt be applied direct to the frog's heart separated from the body—the effect is the same. The weak action of the heart, of course, causes the blood-pressure to diminish, and the heart stops in diastole. The voluntary muscles of the body are also weakened ; the breathing is affected, partly from the action on the muscles. The temperature of the body is depressed (according to F. A. Falck's researches) from 4·4° to 6·2°.

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[*] Taylor, *Guy's Hosp. Reports*, Oct., 1857.

[†] *Op. cit.*

[‡] L. Hermann (*Lehrbuch der Experimentellen Toxicologie*) remarks that the vomiting must be considered as a reflex action from the inflammatory excitement of the digestive apparatus, especially of the stomach. It is witnessed if the poison is administered subcutaneously or injected into the brain. Indeed, it is established that (at least so far as the muscles are concerned) the coördinated movements producing vomiting are caused by excitement of the medulla oblongata. Giannussi and others found that after section between the first and third vertebræ of dogs, and subsequent administration of tartar emetic, no vomiting took place ; and Grimm's researches seem to show that the suspected *vomit-centre* is identical with the respiratory centre, so that the vomiting movement is only an abnormal respiratory movement. L. Hermann, however, considers the theory that when tartar emetic is introduced into the vessels the *vomit-centre* is directly excited, erroneous, for (1) in introducing it by the veins much larger doses are required to excite vomiting than by the stomach ; and (2), after subcutaneous injection of the salt, antimony is found in the first vomit. His explanation, therefore, is that antimony is excreted by the intestinal tract, and in its passage excites this action. Majendie's well-known experiment—demonstrating that, after extirpation of the stomach, vomiting movements were noticed—is not considered opposed to this view.

The effects of small doses given repeatedly to animals has been several times investigated. Dr. Nevin* experimented upon eleven rabbits, giving them tartar emetic four times a day in doses of 33·4 mgrms. (½ grain), 64·8 mgrms. (1 grain), and 129·6 mgrms. (2 grains). Five died, the first after four, the last after seventeen days; three were killed after one, three, and four days respectively, two after an interval of fourteen days, and one thirty-one days after taking the last dose. There was no vomiting; diarrhœa was present in about half the number; one of the rabbits, being with young, aborted. The chief symptoms were general dulness, loss of appetite, and in a few days great emaciation. Four of the five that died were convulsed before death, and several of the animals exhibited ulcers of the mucous membrane of the mouth, in places with which the powder had come in contact. Caillol and Livon have also studied the action of small doses of the white oxide of antimony given in milk to cats. A cat took in this way in 109 days ·628 grm. The animal passed gradually into a cachectic state, diarrhœa supervened, and it died miserably thin and exhausted.

Effects of Tartar Emetic on Man.†—The analogy between the symptoms produced by arsenic and antimony is striking, and in some acute cases of poisoning by tartar emetic, there is but little (if any) clinical difference. If the dose of tartar emetic is very large, there may be complete absence of vomiting, or only a single evacuation of the stomach. Thus, in a case mentioned by Taylor, in which a veterinary surgeon swallowed by mistake 13 grms. (200 grains) of tartar emetic; vomiting after fifteen minutes could only be induced by tickling the throat. So, again, in the case reported by Mr. Freer, a man, aged twenty-eight, took 7·77 grms (120 grains) of tartar emetic by mistake for Epsom salts; he vomited only once; half an hour after taking the poison he had violent pain in the stomach and abdomen, and spasmodic contraction of the abdomen and arms; the fingers were firmly contracted, the muscles quite rigid, and there was involuntary aqueous purging. After six hours, during which he was treated with green tea, brandy, and decoction of oak-bark, he began to recover, but suffered for many nights from profuse perspirations.

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* Lever, *Med. Chir. Journ.*, No. 1.

† Antimony occasionally finds its way into articles of food through obscure channels. Dr. Page has recorded the fact of antimonial lozenges having been sold openly by an itinerant vendor of confectionery. Each lozenge contained nearly a quarter of a grain (·16 mgrms.), and they caused well-marked symptoms of poisoning in the case of a servant and two children. How the antimony got in was unknown. In this case it appears to have existed not as tartar emetic, but as an insoluble oxide, for it would not dialyse in aqueous solution.—("On a remarkable instance of Poisoning by means of Lozenges containing Antimony." By David Page, M.D., Medical Officer of Health, *Lancet*, vol. i., 1879, p. 699).

With more moderate and yet large doses, nausea and vomiting are very prominent symptoms, and are seldom delayed more than half an hour. The regular course of symptoms may therefore be summed up thus :—A metallic taste in the mouth, repeated vomitings, which are sometimes bloody, great faintness and depression, pains in the abdomen and stomach, and diarrhœa, which may be involuntary. If the case is to terminate fatally, the urine is suppressed, the temperature falls, the face becomes cyanotic, delirium and convulsions supervene, and death occurs in from two to six days. Antimony, like arsenic, often produces a pustular eruption. Solitary cases deviate more or less from the course described—*i. e.*, severe cramps affecting all the muscles, hæmorrhage from the stomach, kidney, or bowel and death from collapse in a few hours, have all been noticed. In a case recorded by Mr. Morley,* a surgeon's daughter, aged eighteen, took by mistake an unknown quantity of antimonial wine; she soon felt sleepy and powerless, and suffered from the usual symptoms in combination with tetanic spasms of the legs. She afterwards had enteritis for three weeks, and on recovery her hair fell off. Orfila relates a curious case of intense spasm of the gullet from a large dose of tartar emetic.

Chronic Antimonial Poisoning.—The cases of Palmer and J. P. Cook, M. Mullen, Freeman, Winslow, Pritchard, and the remarkable Bravo case have, in late years, given the subject of chronic antimonial poisoning a considerable prominence. In the trials referred to, it was shown that medical men might easily mistake the effects of small doses of antimony given at intervals for the action of disease—the symptoms being great nausea, followed by vomiting, chronic diarrhœa, alternating with constipation, small frequent pulse, loss of voice, great muscular weakness, depression, with coldness of the skin and a clammy perspiration. In the case of Mrs. Pritchard,† her face was flushed, and her manner so excited as to give an ordinary observer the idea that she had been drinking; and with the usual symptoms of vomiting and purging she suffered from cramps in the hands. Dr. Pritchard tried to make it appear that she was suffering from typhoid fever, which the symptoms in a few respects only resembled.

According to Eulenberg, workmen exposed for a long period to the vapour of the oxide of antimony, suffer pain in the bladder and a burning sensation in the urethra, and continued inhalation even leads to impotence and wasting of the testicles.‡

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* *Brit. Med. Journ.*, Oct. 14, p. 70.

† *Edin. Med. Journ.*, 1865.

‡ In the first operations of finishing printers' types, the workmen inhale a metallic dust, which gives rise to effects similar to lead colic ; and probably in this case the lead is more active than the associated antimony.

Post-mortem Appearances.—The effect of large doses of tartar emetic is mainly concentrated upon the gastro-intestinal mucous membrane. There is an example in the museum of University College Hospital of the changes which resulted from the administration of tartar emetic in the treatment of pneumonia. These are ascribed in the catalogue, in part to the local action of the medicine, and in part to the extreme prostration of the patient. In the preparation (No. 1052) the mucous membrane over the fore border of the epiglottis and adjacent part of the pharynx, has been destroyed by sloughing; the ulceration extends into the upper part of the œsophagus. About an inch below its commencement, the mucous membrane has been entirely removed by sloughing and ulceration, the circular muscular fibres being exposed. Above the upper limit of this ulcer, the mucous membrane presents several oval, elongated, and ulcerated areas, occupied by strips of mucous membrane which have sloughed. In other places, irregular portions of the mucous membrane, of a dull ashen-gray colour, have undergone sloughing; the edges of the sloughing portion are of colours varying from brown to black.

It is seldom that so much change is seen in the gullet and pharynx as this Museum preparation exhibits; but redness, swelling, and the general signs of inflammation are seldom absent from the stomach and some parts of the intestines. On the lining membrane of the mouth, ulcers and pustules have been observed.

In Dr. Nevin's experiments in the chronic poisoning of rabbits already referred to, the *post-mortem* appearances consisted in congestion of the liver in all the rabbits; in nearly all there was vivid redness of the stomach; in two cases there was ulceration; in some, cartilaginous hardness of the pylorus; while, in others, the small intestines presented patches of inflammation. In two of the rabbits the solitary glands throughout the intestines were prominent, yellow in colour, and loaded with antimony. The colon and rectum were healthy, the kidneys congested; the lungs were in most congested, in some actually inflamed, or hepatised and gorged with blood. Bloody extravasations in the chest and abdomen were frequent.

Saikowsky,* in feeding animals daily with antimony, found invariably in the course of fourteen to nineteen days fatty degeneration of the liver, and sometimes of the kidney and heart. In the experiment of Caillol and Livon also all the organs were pale, the liver had undergone fatty degeneration, and the lung had its alveoli filled with large degenerated cells, consisting almost entirely of fat. The mesenteric glands also formed large caseous masses, yellowish-white in colour, which, under the microscope, were seen to be composed of fatty cells, so that there is a complete analogy between the action of arsenic and antimony on the body tissues.

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* Virchow's *Arch. f. Path. Anat.*, Bd xxv.; also, *Centralblatt f. Med. Wissen.*, No. 23, 1865.

Elimination of Antimony.—Antimony is mainly eliminated by the urine. In 1840, Orfila showed to the *Académie de Médecine* metallic antimony, which he had extracted from a patient who had taken ·12 grm. of tartar emetic in twenty-four hours. He also obtained antimony from an old woman, aged eighty, who twelve hours before had taken ·6 grm. (9¼ grains)—a large dose, which had neither produced vomiting nor purging. In Dr. Nevin's experiments on rabbits, antimony was discovered in the urine after the twelfth dose, and even in the urine of an animal twenty-one days after the administration of the poison had been suspended.

Antidotes for Tartar Emetic.—Any infusion containing tannin or allied astringent principles, such as decoctions of tea, oak-bark, &c., may be given with advantage in cases of recent poisoning by tartar emetic, for any of the salt which has been expelled by vomiting, may in this way be decomposed and rendered harmless. The treatment of acute poisoning which has proved most successful, has been the encouraging of vomiting by tickling the fauces, giving strong green tea and stimulants. (See Appendix.)

Effects of Chloride or Butter of Antimony.—Only a few cases of poisoning by butter of antimony are on record: its action, generally speaking, on the tissues is like that of an acid, but there has been considerable variety in the symptoms. Five cases are recorded by Taylor; three of the number recovered after taking respectively doses of 7·7 grms. (2 drachms) and 15·5 grms. (4 drachms), and two died after taking from 56·6 to 113 grms. (2 to 4 ounces). In one of these cases the symptoms were more like those of a narcotic poison, in the other fatal case there was abundant vomiting with purging The autopsy in the first case showed a black appearance from the mouth to the jejunum, as if the parts had been charred, and extensive destruction of the mucous membrane. In the other case there were similar changes in the stomach and the upper part of the intestines, but neither the lips nor the lower end of the gullet were eroded. In a recent case recorded by Mr. Barrington Cooke,* a farmer's wife, aged forty, of unsound mind, managed to elude the watchfulness of her friends and swallowed an unknown quantity of antimony chloride about 1.30 p. m. Shortly afterwards she vomited several times, and had diarrhœa; at 2.30 a medical man found her lying on her back insensible, and very livid in the face and neck. She was retching, and emitting from her mouth a frothy mucous fluid, mixed with ejected matter of a grumous colour ; the breathing was laboured and spasmodic ; the pulse could not be felt, and the body was cold and clammy. She expired at 3.30, about one hour and a half from the commencement of symptoms, and probably within two hours from the taking of the poison. The autopsy showed no corrugation of the tongue or inner surface of the lining membrane of the mouth, and no appearance of the action of a corrosive upon the lips, fauces, or mucous membrane of the œsophagus. The whole of the mucous membrane of the stomach was intensely congested, of a dark and almost black colour, the rest of the viscera were healthy. Chemical analysis separated antimony equivalent to nearly a grm. (15 grains) of the chloride, with a small quantity of arsenic, from the contents of the stomach.

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* *Lancet*, May 19, 1883.

Detection of Antimony in Organic Matters.—In acute poisoning by tartar emetic it is not impossible to find a mere trace only in the stomach, the greater part having been expelled by vomiting, which nearly always occurs early, so that the most certain method is, where possible, to analyse the ejected matters. If it should be suspected that a living person is being slowly poisoned by antimony, it must be remembered that the poison is mainly excreted by the kidneys, and the urine should afford some indication. The readiest way to test is to collect a considerable quantity of the urine (if necessary, two or three days' excretion), concentrate by evaporation, acidify, and then transfer the liquid to a platinum dish, in which is placed a slip of zinc. The whole of the antimony is in time deposited on the platinum dish, and being thus concentrated, may be subsequently identified in any way thought fit.

Organic liquids are boiled with hydrochloric acid ; organic solids are extracted with the same acid in the manner described (p. 51); or, if the distillation process given at p. 515 can be employed, the antimony may be found partly in the distillate, and partly in the retort. In any case, antimony in solution may be readily detected in a variety of ways —one of the most convenient being to concentrate on tin or platinum, to dissolve out the antimonial film by sulphide of ammonium, and thus produce the very characteristic orange sulphide.

If a slip of pure tinfoil be suspended for six hours in a solution, which should not contain more than one-tenth of its bulk of ClH, and exhibit no stain or deposit, it is certain that antimony cannot be present. It may also conveniently be deposited on a platinum dish,[*] by filling the same with the liquid properly acidulated, and inserting a rod of zinc; the metallic antimony can afterwards be washed, dried, and weighed.

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[*] According to Fresenius (*Zeitschr. f. Anal. Chem.*, i., 445), a solution which contains $\frac{1}{10000}$ of its weight of antimony, treated in this way, gives in two minutes a brown stain, and in ten a very notable and strong dark-brown film. When in the proportion of 1 to 20,000, the reaction begins to be certain after a quarter of an hour; with greater dilution it requires longer time, 1 to 40,000 giving a doubtful reaction, and 1 to 50,000 not responding at all to this test.

Reinsch's and Marsh's tests have been already described (pp. 500 and 497), and require no further notice. There is, however, a very beautiful and delicate means of detecting antimony, which should not be omitted. It is based upon the action of stibine (SbH_3) on sulphur.* When this gas is passed over sulphur, it is decomposed according to equation, $2SbH_3+6S=Sb_2S_3+3SH_2$, the action taking place slowly in diffused daylight, but very rapidly in sunshine. An ordinary flask for the evolution of hydrogen (either by galvanic processes or from zinc and sulphuric acid), with its funnel and drying-tubes, is connected with a narrow tube having a few fragments of sulphur, kept in place by plugs of cotton wool. The whole apparatus is placed in sunshine; if no orange colour is produced when the hydrogen has been passing for some time, the liquid to be tested is poured in gradually through the funnel, and if antimony should be present, the sulphur acquires a deep orange colour. This is distinct even when so small a quantity as ·0001 grain has been added through the funnel. The sulphide of antimony thus mixed with sulphur can, if it is thought necessary, be freed from the sulphur by repeated exhaustion with bisulphide of carbon. The stibine does not, however, represent all the antimony introduced, a very large proportion remaining in the evolution flask;† hence it cannot be employed for quantitative purposes. Moreover, the test can, of course, only be conveniently applied on sunny days, and is, therefore, in England more adapted for summer.‡ Often, however, as mentioned elsewhere, when the analyst has no clue whatever to the nature of the poison, it is convenient to pass SH_2 in the liquid to saturation.§ In such a case, if antimony is present (either alone or in combination with other sulphides), it remains on the filter, and must be separated and identified as follows:—The sulphides are first treated with a solution of carbonate of ammonia, which will dissolve arsenic, if present, and next saturated *in situ* with pure sulphide of sodium, which will dissolve out sulphide of antimony, if present. The sulphide of antimony will present the chemical characters already described, more particularly.

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* See Ernest Jones on "Stibine," *Journ. Chem. Soc.*, vol. i., 1876.

† Rieckter, *Jahresbericht*, 1865, p. 255.

‡ The action of salts of cæsium with chloride of antimony might be used as a test for the latter. A salt of cæsium gives a white precipitate with chloride of antimony in concentrated ClH; it contains 30·531 per cent. of antimony, and corresponds to the formula $SbCl_3CsCl$. Chloride of tin acts similarly.—E. Godeffroy: *Berichte der deutschen Gesellschaft*. Berlin, 1873.

§ The solution must not be too acid.

(1.) It will evolve SH_2 when treated with HCl, and at the same time pass into solution.*

(2.) The solution evaporated to get rid of free HCl gives with water a thick cheesey precipitate of basic chloride of antimony. This may be seen if only a drop or two of the solution be taken and tested in a watch-glass.

(3.) If tartaric acid be added to the solution, this precipitation does not occur.

(4.) The solution from (3) gives an orange precipitate with SH_2.

Such a substance can only be sulphide of antimony. With regard to (2), bismuth would act similarly, but under the circumstances could not be present for the sulphide of bismuth is insoluble in sodic sulphide.

Quantitative Estimation.—The quantitative estimation of antimony is best made by some volumetric process—*e.g.*, the sulphide can be dissolved in HCl, some tartrate of soda added, and then carbonate of soda to weak alkaline reaction. The strength of the solution of tartarised antimony thus obtained can now be estimated by a decinormal solution of iodine, the end reaction being indicated by the previous addition of a little starch solution, or by a solution of permanganate of potash, either of which should be standardised by the aid of a solution of tartar emetic of known strength.

3. CADMIUM.

Cadmium, Cd = 112; specific gravity, 8·6 to 8·69; fusing point, 227·8° (442°F.); boiling point, 860° (1580°F.)—Cadmium in analysis is seldom separated as a metal, but is estimated either as oxide or sulphide.

Cadmium Oxide, CdO = 128—cadmium 87·5 per cent., oxygen 12·5 per cent.—is a yellowish or reddish-brown powder, non-volatile even at a white heat; insoluble in water, but dissolving in acids. Ignited on charcoal, it is reduced to metal, which volatilises, and is then deposited again as oxide, giving to the coal a distinct coat of an orange-yellow colour in very thin layers—in thick layers, brown.

Cadmium Sulphide, CdS = 144—Cd 77·7 per cent., S 22·3 per cent.—known as a mineral termed Greenockite. When prepared in the wet way it is a lemon-yellow powder, which cannot be ignited in hydrogen without loss, and is insoluble in water, dilute acids, alkalies, alkaline

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* By adding chloride of tin to a solution of chloride of antimony in sufficient quantity, and passing SO_2 through the liquid, the whole of the antimony can be thrown down as sulphide, whilst the tin remains in solution. Thus,—

$$9SnCl_2+2SbCl_3+3SO_2+12ClH=Sb_2S_3+9SnCl_4+6OH_2.$$

—Federow: *Zeitschrift für Chemie*, 1869, p. 16.

sulphides, sulphate of soda, and cyanide of potassium. The solution must not contain too much hydrochloric acid, for the sulphide is readily soluble with separation of sulphur in concentrated hydrochloric acid. It may be dried in the ordinary way at 100° without suffering any decomposition,

Medicinal Preparations.—The Iodide of Cadmium (CdI_2) occurs in white, flat, micaceous crystals, melting at about 215·5° (419·9°F.), and at a dull read heat giving off violet vapour. In solution the salt gives the reactions of iodine and cadmium. The B.P. states that 10 grains dissolved in water give a precipitate, which, after being washed with water, and then with half an ounce of solution of ammonium, and dried, weighs 12·5 grains (or 1 grm. gives a silver precipitate weighing 1·25 grm.). The ointment of iodide of cadmium (*Unguentum cadmii iodidi*) contains the iodide in the proportion of 62 grains to the ounce or 14 per cent.

Cadmium Sulphate is officinal in the German and French pharmacopœias

Cadmium in the Arts, &c.—Cadmium is used in various alloys. The sulphide is found as a colouring ingredient in certain toilet-soaps, and is much valued by artists as a pigment. The iodide of cadmium is employed in photography and an amalgam of metallic cadmium to some extent in dentistry.

Fatal Dose of Cadmium.—Although no deaths from the use of cadmium appear to have as yet occurred, its growing use in photography, &c., may lead to accidents. There can be no question about the poisonous action of cadmium, for Marmé,[*] in his experiments on it with animals, observed giddiness, vomiting, syncope, difficulty in respiration, loss of consciousness, and cramps. The amount necessary to destroy life can only be gathered from the experiments on animals. A strong hound died after the injection of ·03 grm. (·462 grain) subcutaneously of a salt of cadmium; rabbits are poisoned if from 19·4 to 38·8 mgrms. (·3 to ·6 grain) are introduced into the stomach. A watery solution of ·5 grm. (7·5 grains) of the bromide administered to a pigeon caused instant death, without convulsion; the same dose of the chloride killed a second pigeon in six minutes; ·25 grm. (3·85 grains) of sulphite of cadmium administered to a pigeon excited vomiting, and after two hours diarrhœa; it died in eight days. Another pigeon died from a similar dose in fourteen days, and cadmium, on analysis, was separated from the liver. From the above cases it would seem probable that 4 grms. (61·7 grains) would be a *dangerous* dose of a soluble salt of cadmium for an adult, and that in a case of chronic poisoning it would most probably be found in the liver.

[*] *Zeitschr. f. Rationelle Med.* vol. xxix., p. 1, 1867

Separation and Detection of Cadmium.—If cadmium be in solution, and the solution is not too acid, on the addition of SH_2 there is precipitated a yellow sulphide, which is distinguished from antimony and arsenical sulphides by its insolubility in ammonia and alkaline sulphides. Should all three sulphides be on the filter (an occurrence which will seldom, perhaps, never, happen) the sulphide of arsenic can be dissolved out by ammonia, the antimony by sulphide of sodium, leaving the sulphide of cadmium as the residue.*

The further tests of the sulphide are :—

(1.) It dissolves in dilute nitric acid to a colourless fluid, with separation of sulphur.

(2.) The solution, filtered and freed from excess of nitric acid by evaporation, gives with a solution of ammonic carbonate a white precipitate of carbonate of cadmium insoluble in excess. This distinguishes it from zinc, which gives a similar white precipitate, but is soluble in the excess of the precipitant.

(3.) The carbonate thus obtained, heated on platinum foil, is changed into the brown-red non-volatile oxide.

(4.) The oxide behaves on charcoal as already detailed.

(5.) A metallic portion can be obtained by melting the oxide with cyanide of potassium; it is between zinc and tin in brilliancy, and makes a mark on paper like lead, but not so readily. There are many other tests, but the above are conclusive.

If cadmium in any case be specially searched for in the organs or tissues, the latter should be boiled with nitric acid. The acid solution is filtered, saturated with caustic potash, evaporated to dryness, and ignited; the residue is dissolved in dilute hydrochloric acid, and treated after filtration with SH_2. Cadmium may also be estimated volumetrically by digesting the sulphide in a stoppage flask with ferric chloride and hydrochloric acid; the resulting ferrous compound is titrated with permanganate, each cc. of a d.n. solution of permanganate = ·0056 grm. of cadmium.

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*It is unnecessary to state that absence of sulphur is presupposed.

II.—PRECIPITATE BY HYDRIC SULPHIDE IN HYDROCHLORIC ACID SOLUTION—BLACK.

LEAD—COPPER—BISMUTH—SILVER—MERCURY.

1. LEAD.

Lead Pb = 207.—Lead is a well-known bluish-white, soft metal; fusing point, 325°; specific gravity, 11·36.

Oxide of Lead.—The two oxides of lead necessary to notice here briefly are—litharge and minium.

Litharge, or Oxide of Lead, PbO = 223; specific gravity, 9·2 to 9·5—Pb 92·82 per cent., O 7·18—is either in crystalline scales, a fused mass, or a powder, varying in colour (according to its mode of preparation) from yellow to reddish-yellow or orange. When prepared below the temperature of fusion it is called "*Massicot.*" It may be fused without alteration in weight; in a state of fusion it dissolves silicic acid and silicates of the earths. It must not be fused in platinum vessels.

Minium, or Red Lead, 2PbO, PbO_2; specific gravity 9·08, is a compound of protoxide of lead with the dioxide. It is of a brilliant red colour, much used in the arts, and especially in the preparation of flint-glass.

Sulphide of Lead, PbS=239; Pb 86·61 per cent.; S 13·39 per cent., occurring in the usual way, is a black precipitate insoluble in water, dilute acids, alkalies, and alkaline sulphides. It dissolves in strong nitric acid with a separation of sulphur, and in strong hydrochloric acid, with evolution of SH_2. Fuming nitric acid does not separate sulphur, but converts the sulphide into sulphate.

Sulphate of Lead, $PbSO_4$ = 303; specific gravity, 6·3; PbO 73·61 per cent., SO_3 26·39 per cent.; when produced artificially is a heavy white powder, of great insolubility in water, 22,800 parts of cold water dissolving only one of lead sulphate; and if the water contains sulphuric acid, no less than 36,500 parts of water are required. The salts of ammonia (especially the acetate and tartrate) dissolve the sulphate, and it is also soluble in hyposulphite of soda. The sulphate can be readily changed into the carbonate of lead, by boiling it with solutions of the alkaline carbonates. The sulphate of lead, fused with cyanide of potassium, yields metallic lead; it may be also reduced on charcoal, and alone it may be fused without decomposition, provided reducing gases are excluded.

Acetate of Lead, Sugar of Lead $Pb(C_2H_3O_2)_2 3OH_2$, is found in commerce in white, spongy masses composed of acicular crystals. It may, however, be obtained in flat four-sided prisms. It has a sweet metallic taste, is soluble in water, and responds to the usual tests for lead. The P. B. directs that 38 grains dissolved in water, require, for complete precipitation, 200 grain measures of the volumetric solution of oxalic acid, corresponding to 22·3 grains of oxide of lead.

Chloride of Lead, $PbCl_2=278$; specific gravity, 5·8—Pb 74·48 per cent., Cl 25·52 per cent.; is in the form of brilliant crystalline needles. It is very insoluble in cold water containing hydrochloric or nitric acids. According to Bischof, 1635 parts of water containing nitric acid dissolve one part only of chloride of lead. It is insoluble in absolute alcohol, and sparingly in alcohol of 70 to 80 per cent. It fuses below red heat without losing weight; at higher temperatures it may be decomposed.

Carbonate of Lead.—The commercial carbonate of lead (according to the recent very exhaustive researches of Wigner and Harland*) is composed of a mixture of neutral carbonate of lead and hydrate of lead, the best mixture being 25 per cent. of hydrate, corresponding to an actual percentage of 12·3 per cent of carbonic acid. The nearer the mixture approximates to this composition the better the paint; whilst samples containing as much as 16·33 per cent., or as little as 10·39 per cent., of CO_2 are practically useless.

Preparations of Lead used in Medicine, the Arts, &c.

(1.) *Pharmaceutical:—*

Lead Plaster (*Emplastrum plumbi*) is simply a lead soap in which the lead is combined with oleic and margaric acids.

Lead Iodide, PbI_2, is contained in the *Emplastrum plumbi iodidi,* to the extent of 20 per cent., and in the *Unguentum plumbi iodidi* to the extent of about 11·4 per cent.

Acetate of Lead is contained in a pill, a suppository, and an ointment. The pill, *Pilula plumbicum opio,* contains 74 per cent. of lead acetate, and 12·5 per cent of opium, the rest confection of roses. The suppository (*Suppositoria plubi composita*) contains 20 per cent. of acetate of lead, and 10 per cent. of opium, mixed with oil of theobroma, white wax, and benzoated lard. The ointment (*Unguentum plumbi acetatis*) contains 24 per cent. of lead acetate, mixed with benzoated lard.

The solution of subacetate of lead (*Liquor plumbi subacetatis*) is the subacetate, $Pb(C_2H_3O_2)_2PbO$, dissolved in water. The P. B. states that 413·3 grains by weight (6 fluid drachms) require for perfect precipitation 810 grain measures of the volumetric solution of oxalic acid, corresponding to about 30 grains of lead. In other words, the solution must contain at least 8·1 per cent. of oxide of lead.

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* "On the Composition of Commercial Samples of White Lead," by G. W. Wigner and R. H. Harland.—*Analyst,* 1877, p. 208.

A dilute solution of the stronger, under the name of *Liquor plumbi subacetatis dilutus*, and commonly called Goulard water, is prepared by mixing 1·25 part (by volume) of the solution, and 1·25 part of spirit, and making up to 100 parts with distilled water.

There is an ointment, called the *Compound Ointment of subacetate of lead*, which contains the subacetate in about the proportion of 2 per cent. of the oxide, the other constituents being camphor, white wax, and almond oil.

Carbonate of Lead.—The ointment (*Unguentum plumbi carbonatis*) should contain about 11·4 per cent. of the carbonate, and the rest simple ointment.

(2.) *Quack Nostrums, &c.* :—

The quack medicines composed of lead are not very numerous.

Liebert's *Cosmetique Infallible* is said to have for its basis nitrate of lead.

One of "*Ali Ahmed's Treasures of the Desert,*" viz., the antiseptic malagma, is a plaster made up of lead plaster 37·5 per cent., frankincense 25 per cent., salad oil 25 per cent., beeswax 12·5 per cent.

Lewis' Silver Cream contains white precipitate and a salt of lead.

Goulard's Balsam is made by triturating acetate of lead with hot oil of turpentine

There are various ointments in use made up of litharge. Some herbalists in the country (from cases that have come under the writer's own knowledge) apply to cancerous ulcers, &c., a liniment of linseed and other common oils mixed with litharge and acetate of lead.

Acetate of lead may also be found as a constituent of various eye-waters.

(3.) *Preparations of Lead used in the Arts, &c.* :—

Ledoyen's Disinfecting Fluid has for its basis nitrate of lead.

In various hair-dyes the following are all used :—Litharge, lime, and starch ; lime and carbonate of lead ; lime and acetate of lead ; litharge, lime, and potassic bicarbonate. The detection of lead in the hair thus treated is extremely easy ; it may be dissolved out by dilute nitric acid.

Lead Pigments.—The principal pigments of lead are white, yellow, and red.

White Pigments :—

White Lead, Flake White Ceruse, Mineral White, are so many different names for the carbonate of lead already described.

Newcastle White is white lead made with molasses vinegar.

Nottingham White.—White lead made with alegar (sour ale), often, however, replaced by permanent white, *i. e.*, sulphate of baryta.

Miniature Painters' White, White Precipitate of Lead, is simply lead sulphate.

Pattison's White is an oxychloride of lead, $PbCl_2PbO$.

Yellow Pigments :—

Chrome Yellow may be a fairly pure chromate of lead, or it may be mixed with sulphates of lead, barium, and calcium. The pigment known as "Cologne yellow," consists of 25 parts of lead chromate, 15 of lead sulphate, and 60 of calcic sulphate. The easiest method of analysing chrome yellow is to extract with boiling hydrochloric acid in the presence of alcohol, which dissolves the chromium as chloride, and leaves undissolved chloride of lead, sulphate of lead, and other substances insoluble in ClH. Every grain of chromate of lead should yield 0·24 grain of oxide of chromium, and 0·4 grain of chloride of lead.

Turner's Yellow, Casella Yellow, Patent Yellow, is an oxychloride of lead ($HbCl_27PbO$) extremely fusible.

Dutch Pink sometimes contains white lead.

Red Pigments :—

Chrome Red is a bichromate of lead.

Red Lead or *Minium* is the red oxide of lead.

Orange Red is an oxide prepared by calcining the carbonate.

The chief preparations of lead which may be met with in the arts, in addition to the oxides and the carbonate, are—

The *Nitrate of Lead,* much used in calico-printing.

The *Pyrolignite of Lead,* which is an impure acetate used in dyeing; and

The *Sulphate of Lead* is a by-product in the preparation of acetate of aluminium for dyeing.

The alloys containing lead are extremely numerous; but, according to the experiments of Knapp.* the small quantity of lead in those used for household purposes has no hygienic importance.

Lead as a Poison.—In the five years ending 1880, there were registered 324 deaths from lead poisoning in England (255 males and 69 females). This is about 20 per cent. of the deaths from all poisons. Only one of the 324 was accidental, and none were criminal. All the compounds of lead are said to be poisonous; but this statement cannot be regarded as entirely correct, for the sulphocyanide has been proved by experiment not to be so,* and the sulphide is probably inactive. In the treatment of cases of lead poisoning, however, the flowers of sulphur given internally appear to be successful.†

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* *Dingl. Polytech. Journ.*, vol. ccxx., pp. 446-453.

Lead poisoning, either in its obscure form (producing uric acid in the blood, and, as a consequence, indigestion and other evils), or in the acute form (as lead colic and various nervous affections), is most frequent among those who are habitually exposed to the influence of the metal in its different preparations—viz., workers of lead, house-painters, artists, gilders, workers of arsenic, workers of gold, calico-printers, colourists, type-founders, type-setters, shot-founders, potters, faience makers, braziers, and many others.‡ Recently, in the white lead factories in London, so large a number of the employes suffered from poisoning that it has been one of the most common maladies to be seen in certain east-end hospitals and infirmaries, and has excited the attention of the Government (1883).

Lead, again, has been found by the analyst in most of the ordinary foods, such as flour, bread, beer, cider, wines, spirits, tea, vinegar, sugar, confectionery, &c., as well as in numerous drugs, especially those manufactured by the aid of sulphuric acid (the latter nearly always containing lead), and those salts or chemical products which (like citric and tartaric acids) are crystallised in leaden pans. Hence it follows that in almost everything eaten or drunk the analyst, as a matter of routine, tests for lead. The channels through which it may enter into the system are, however, so perfectly familiar to practical chemists, that a few *unusual* instances of lead-poisoning only need be quoted here.

A cabman suffered from lead colic, traced to his taking the first glass of beer every morning at a certain public house ; the beer standing in the pipes all night, as proved by analysis, was strongly impregnated with lead.§

The employment of red lead for repairing the joints of steam pipes has before now caused poisonous symptoms from volatilisation of lead.‖ The use of old painted wood in a baker's oven, and subsequently adherence of the oxide of lead to the outside of the loaves, has recently caused the illness of sixty-six people.*

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* Eulenberg, *Gewerbe Hygiène*, p. 712.

† Mohr's *Toxocologie*, p. 78.

‡ The attention which the use of lead in the arts has always excited is evident from the fact that one of the oldest works on Trade Hygiene (by Stockhausen) is entitled, *De lithargyrii fumo noxio, morbifico ejusque metallico frequentiori morbo vulgo dicto hüttenkatze.* Gaslar, 1556.

§ *Chem. News.*

‖ Eulenberg, *Op. Cit.*, p. 780.

Seven persons became affected with lead poisoning through horsehair coloured with lead.†

The manufacture of *American overland cloth* creates a white-lead dust, which has caused serious symptoms among the workmen (*Dr. G. Johnson*). The cleaning of pewter pots,‡ the handling of vulcanised rubber,§ the wrapping up of various foods in tin foil,‖ and the fingering of lead counters covered with brine by fishmongers, have all caused accidents in men.

The lead in glass, though in the form of an insoluble silicate, is said to have been dissolved by vinegar and other acid fluids to a dangerous extent. This, however, is hardly well established.¶

Effects of Lead Compounds on Animals.—Orfila and the older school of toxicologists made a number of experiments on the action of sugar of lead and other compounds, but they are of little value for elucidating the physiological or toxic action of lead, because they were, for the most part, made under unnatural conditions, the gullet being ligatured to avoid expulsion of the salt by vomiting. One of the latest experimenters is Harnack, who, in order to avoid the local and corrosive effects of sugar of lead, used an organic compound—viz., plumbic triethyl acetate, which has no local action. Frogs exhibited symptoms after subcutaneous doses of from 2 to 3 mgrms., rabbits after 40 mgrms. ; there was increased peristaltic action of the intestines, with spasmodic contraction rising to colic, very often diarrhœa and death followed through heart paralysis. Dogs given the ethyl compound exhibited nervous symptoms like chorea. Gusserno** has also made experiments on animals as to the effects of lead, using lead phosphate, and giving from 1·2 grm. to a rabbit and a dog daily. Rosenstein†† and Heubel‡‡ used small doses of acetate, the latter giving dogs daily from ·2 to ·5 grm. The results arrived at by Gusserno were, mainly, that the animals became emaciated, shivered, and had some paralysis of the hinder extremities; while Rosenstein observed towards the end epileptiform convulsions, and Heubel alone saw, in a few of his cases, colic. A considerable number of cattle have been poisoned from time to time with lead, and one instance of this fell under my own observation. A pasture had been manured with refuse from a plumber's yard, and pieces of paint were in this way strewn about the field in every direction; a herd of fifteen young cattle were placed in the field, and in two or three days they all, without exception, began rapidly to lose condition, and to show peculiar symptoms—diarrhœa, loss of appetite; in two, blindness, the retina presenting an appearance not unlike that seen in Bright's disease; in three, a sort of delirium. Four died, and showed on *post-mortem* examination granular conditions of the kidneys, which was the most striking change observable. In the fatal cases, paralysis of the hind extremities, coma, and convulsions preceded death. In another case * seven cows and a bull died from eating lead paint; the symptoms were loss of appetite, obstinate constipation, suspension of rumination, dry muffle, quick breathing, and coma. In other cases a marked symptom has been paralysis. Cattle † have also several times been poisoned from eating grass which has been splashed by the spray from bullets, as in pastures in the vicinity of rifle butts; here we must allow that the intestinal juices have dissolved the metal, and transformed it into compounds capable of being taken into the system.

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* *Annales d'Hygiène.*

† Hitzig, "Studien über Bleivergiftung."

‡ *Med. Gazette*, xlviii. 1047.

§ *Pharm. Journ.* 1870, p. 426.

‖ Taylor, "Prin. Med. Jurisprud.," I.

¶ See *Aertzl. Intelligenzbl. f. Baiern*, Jahrg., 1869 ; *Buchner's Rep. Pharm.* Bd. xix., p. 1 ; *Med. Centrbl.*, Jahrg., 1860, p. 40.

** Virchow's *Archiv f. Path. Anat.*, vol. xxi., p. 443.

†† *Ib.*, vol. xxxix., pp. 1 and 74.

‡‡ *Pathogenese u. Symptome der chronischen Bleivergiftung.* Berlin, 1871.

Effects of Lead Compounds on Man—Acute Poisoning.—Acute poisoning by preparations of lead is not common, and, when it does occur, is seldom fatal. With regard to the common acetate, it would seem that a large single dose is less likely to destroy life than smaller quantities given in divided doses for a considerable period. The symptoms produced by a considerable dose of sugar of lead usually commence within a few minutes; there is immediately a metallic taste, with burning, and a sensation of great dryness in the mouth and throat; vomiting, which occurs usually within fifteen minutes, is in very rare cases delayed from one to two hours. The retching and vomiting are very obstinate, and continue for a long time; the matters thrown up are sometimes streaked with blood; there is pain in the abdomen of a colicky character—a pain relieved by pressure. The bowels are, as a rule, constipated, but occasionally relaxed. The stools at a later date are black from the presence of lead sulphide. The urine, as a rule, is diminished. The breath has a foul odour, and the tongue is coated; the skin is dry, and the pulse small and frequent. The full development of the toxic action is completed by the appearance of various nervous phenomena—headache, shooting pains in the limbs, cramps in the legs, and local numbness. All the symptoms enumerated are not present in each case; the most constant are the vomiting and the colic. If the sufferer is to die, death occurs about the second or third day. If the patient recovers, convalescence may be much retarded, as shown in the case of two girls,[*] who had each swallowed an ounce of lead acetate by mistake, and who suffered even after the lapse of a year from pain and tenderness in the stomach and sickness.

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* See a paper by Professor Tuson, *Veterinarian*, vol. xxxviii., 1861.

† *Ib.*, also Taylor. *Op cit.*

There are "mass-poisonings" by acetate of lead on record, which afford considerable insight into the varying action of this salt on different individuals. A case (*e.g.*) occurred at Stourbridge in 1840,[†] in which no less than 500 people were poisoned by thirty pounds of lead acetate being accidentally mixed with eighty sacks of flour at a miller's. The symptoms commenced after a few days; constriction of the throat, cramping and twisting pains round the umbilicus, rigidity of the abdominal muscles, dragging pains at the loins, cramps and paralysis of the lower extremities. There was obstinate constipation; the urine was scanty and of a deep red colour, and the secretions were generally arrested; the pulse was slow and feeble; the countenance depressed, often livid; and the gums showed the usual blue line. The temperature of the skin was low. In only a few cases was there sickness, and in these it soon ceased. It is curious that not one of the 500 cases proved fatal, although some of the victims were extremely ill, and their condition alarming. It was specially observed that, after apparent convalescence, the symptoms without any obvious cause suddenly returned, and this even in a more aggravated form. Remittance of this kind is of medico-legal import; it might, for example, be wrongly inferred that a fresh dose had been taken. In the 500 cases, there were no inflammatory symptoms; complete recovery took some time. On examining the bread the poison was found so unequally distributed that no idea could be formed as to the actual amount taken.

There is also recorded [‡] an outbreak of lead poisoning among 150 men of the 7th Infantry at Tione, in the Southern Tyrol. One case proved fatal, forty-five required treatment in hospital. The symptoms were pallor, a blue line in the gums, metallic taste in the mouth, a peculiar odour of the breath, a loaded tongue with a bluish tint, obstinate constipation with loss of appetite; whilst all complained, in addition, of dragging of the limbs and of the muscles of the chest, and difficulty of breathing. In the severer cases there were tetanic spasms, muscular tremors, and anæsthesia of the fingers and toes. The pulse and temperature were normal, save in a few cases in which there were fever and sweats at night. *In none was there colic,* but the constipation was obstinate. In two of the worst cases there was strangury. Acute cases occur occasionally from poisoning by *the carbonate of lead.* Dr. Snow recorded an instance (in 1844) of a child who had eaten a piece as big as a marble, ground up with oil. For three days the child suffered from pain in the abdomen and vomiting, and died ninety hours after taking the poison. In another case, in which a young man took from 19 to 20 grms. of lead carbonate in mistake for chalk as a remedy for heartburn, the symptoms of vomiting, pain in the stomach, &c., commenced after a few hours; but, under treatment with magnetic sulphate, he recovered.

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[*] *Prov. Med. Journal*, 1846.

[†] Recorded by Mr. Bancks, *Lancet*, May 5, 1849, p. 478.

[‡] Königschmied, *Centralbl. Allg. für Gesundheitspflege*, 2 Jahrg., Heft. 1.

The *chromate of lead* is still more poisonous (see Art. "Chromium."

Chronic Poisoning by Lead.—Chronic poisoning by lead—often caused by strange and unsuspected channels, more frequently an incident, nay, almost a necessity of certain trades, and occasionally induced by a cunning criminal for the purpose of simulating natural disease—is of great toxicological and hygiènic importance. In the white lead trade it is, as might be expected, most frequently witnessed; but also in all occupations which involve the daily use of lead in almost any shape. The chief signs of chronic poisoning are those of general ill-health; the digestion is disturbed, the appetite lessened, the bowels obstinately confined, the skin assumes a peculiar yellowish hue, and sometimes the sufferer is jaundiced. The gums show a black line from two to three lines in breadth, which microscopical examination and chemical tests alike show to be composed of sulphide of lead; occasionally the teeth turn black. The pulse is slow, and all secretions are diminished. Pregnant women have a tendency to abort. There are also special symptoms, one of the most prominent of which is often lead colic.

In 142 cases of lead-poisoning, treated between 1852 and 1862 at the Jacob's Hospital, Leipzig, forty-four patients (or about 31 per cent.) suffered from colic. Arthralgia—that is, pains in the joints—is also very common; it seldom occurs alone, but in combination with other symptoms. Thus in seventy-five cases of lead-arthralgia treated at Jacob's Hospital, in only seven were pain in the joints without other complications, fifty-six being accompanied by colic, five by paralysis, and seven by other affections of the nervous system. The total percentage of cases of lead poisoning, in which arthralgia occurs, varies from 32 to 57 per cent.

Paralysis in some form or other, Tanqueril found in 5 to 8 per cent. of the cases, and noticed that it occurred as early as the third day after working in lead. The muscles affected are usually those of the upper extremity, then the legs, and still more rarely the muscles of the trunk. It is only exceptionally that the paralysis extends over an entire limb; it more usually affects a muscular group, or even a single muscle. Its common seat is the extensors of the hand and fingers; hence the expression "dropped-wrist," for the hands droop, and occasionally the triceps and the deltoid are affected. The paralysis is usually symmetrical on both sides. Although the extensors are effected most, the flexors nearly always participate, and a careful investigation will show that they are weakened. If the paralysis continues, there is a wasting and degeneration of the muscle, but this is seen in paralysis from any cause. The muscular affection may cause deformities in the hands, shoulders, &c. Anæsthesia of portions of the skin is generally present in a greater or less degree. A complete analgesia affecting the whole body has been noticed to such an extent, that there was absolute insensibility to burns or punctures; but it is usually confined to the right half of the body, and is especially intense in the right hand and wrist.

The older writers recognised the toxic effect of lead on the nervous system. Thus Dioscorides speaks of delirium produced by lead, Aretaeus of epilepsy, and Paul of Ægina refers to it is a factor of epilepsy and convulsions. But in 1830, Tanqueril first definitely described the production of a mental disease, which he called *"lead encephalopathy."* This he divided into four forms—(1) A delirious form; (2) a comatose; (3) a convulsive; and (4) a combined form, comprising the delirious, convulsive, and comatose. Dr. Henry Rayner,* and a few other English alienists, have recently directed their attention to this question; and, acconding to Dr. Rayner s researches, the number of male patients admitted into Hanwell Asylum, engaged in trades such as plumbing, painting, and the like, is larger in proportion to the number admitted from other trades than it should be, compared with the proportion of the various trades in the county of Middlesex, as ascertained from the census of 1871. Putting aside coarse lead poisoning, which may occasionally produce acute mania, the insanity produced by prolonged minute lead intoxications possesses some peculiar features. It develops slowly, and in nearly all cases there are illusions of the senses, of hearing, taste, or smell, and especially of sight. Thus, in one of Dr. Rayner's cases the patient saw round him "wind-bags blown out to look like men," apparitions which made remarks to him, and generally worried him. Besides this form, there is also another which closely resembles general paralysis, and, in the absence of the history, might be mistaken for it.

The degenerative influence on the organ of sight is shown in six of Dr. Robertson's patients, whose insanity was ascribed to lead—four of the six were either totally or partially blind.

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*See an important paper, "Insanity from Lead Poisoning," by Drs. H. Rayner, Robertson, Savage, and Atkins. *Journ. of Mental Science*, vol. xxvi., p. 222; also a paper by Dr. Barton, *Allgemeine Zeitschrift für Psychiatrie*, Bd. xxxvii., H. 4, p. 9.

The amaurosis has been known to come on suddenly, and after a very brief exposure to lead—*e.g.*, a man, thirty-four years of age, after working for three days in a white lead factory, was seized with intense ciliary neuralgia, had pains in his limbs and symptoms of lead poisoning, and the right eye became amaurotic.* This form of impairment or loss of vision is different from the *Retinitis albuminurica*,† which may also be produced as a secondary effect of the poison; the kidneys in such cases being profoundly affected.

Eulenberg speaks of the sexual functions being weakened, leading to more or less impotence.

Lewy,‡ in 1186 patients suffering from lead poisoning, has found caries or necrosis in twenty-two cases, or about 1·8 per cent.; fifteen were carious affections of the upper jaw, four of the fore-arm, two of the thigh, and one of the rib and sternum. Epilepsy and epileptiform convulsions occur in a few cases; it is very possible that the epilepsy may be a result of the uræmic poisoning induced by diseased kidneys.

Lead taken for a long time causes the blood to be impregnated with uric acid. In one hundred and thirty-six cases of undoubted gout, 18 per cent. of the patients were found to follow lead occupations, and presented signs of lead impregnation.§

There are some facts on record which would seem to countenance the belief that disease primarily caused by an inorganic body like lead may be transmitted. M. Paul (*e. g.*) has related the history of the offspring (thirty-two in number) of seven men, who were suffering from lead poisoning—eleven were prematurely born and one still-born; of the remaining twenty, eight died in the first year, four in the second, and five in the third year, so that of the whole thirty-two, only three survived three years.

The influence of the poison on pregnant women is, indeed, very deleterious. M. Paul noted that in four women who were habitually exposed to the influence of lead, and had fifteen pregnancies, ten terminated by abortion, two by premature confinement, three went the full term, but one of the three children was born dead, a second only lived twenty-hours; so that, out of the whole fifteen, one only lived fully. In another observation of M. Paul's, five women had two natural confinements before being exposed to lead. After exposure, the history of the thirty-six pregnancies of these women is as follows:—There were twenty-six abortions (from two to five months), one premature confinement, two infants born dead, and five born alive, four of whom died in the first year.

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* Samelsohn *Monatsbl. f. Augenheilk.*, vol. xi., p. 246, 1873. See also a case of lead amaurosis, described by Mr. W. Holder, *Pharm. Journal*, Oct. 14, 1876.

† Ran. *Arch. f. Ophthal.*, vol. , (2), p. 205, 1858, and Schmidt's *Jahrbuch*, Bd. cxxxiii., p. 116; Bd. cxliii, p. 67.

‡ *Die Berufskrank. d. Bleiarbeiter.* Wien, 1873, S. 61.

§ "On Lead Impregnation in Relation to Gout," by Dyce Duckworth, M. D., *St. Barth. Hosp. Reports*, vol. xvii., 1881.

Chronic poisoning may be nearly always accounted for by the inhaling of lead dust, or by the actual swallowing of some form of lead; but, if we are to accept the fact narrated by the late Dr. Taylor—viz., that he himself had an attack of lead colic from sitting in a room for a few hours daily, in which there was a large canvas covered with white lead and drying oil, and one or two similar cases,* we must allow that there is some subtle volatile organic compound of lead evolved. In the present state of our knowledge, it seems more reasonable to account for such cases, by the suggestion that lead has entered the system by an unsuspected channel.

In 1882, a very interesting case occurred at Keighley, in which a mechanic, aged forty-two, died from the supposed effects of lead poisoning, induced from drinking the town water, which was proved by Mr. Allen to contain about $\frac{3}{5}$ of a grain of lead per gallon. For six months he had been out of health, and a week before his death he suffered from colic, vomiting, constipation, and a blue line round the gums, and occasional epileptiform seizures. After death the kidneys were found granular, and the heart somewhat enlarged. The viscera were submitted to Mr. Allen for analysis; no lead was found in the heart or brain, a slight non-estimable trace in the kidneys, and about a grain was separated from the liver and spleen. Dr. Tidy, who was called in as an expert, gave a very guarded opinion, rather against the theory of direct lead poisoning; and the verdict returned by the jury was to the effect that the deceased died from granular kidney, accelerated by lead poisoning. Murder by the administration of doses of sugar of lead is rare, but such a case occurred recently.

At the Central Criminal Court, in December, 1882, Louisa Jane Taylor, was indicted for poisoning Mary Ann Tregillis at Plumbstead, and convicted. From the evidence it appeared that the prisoner, who was thirty-six years of age, came to reside with Mr. and Mrs. Tregillis, an aged couple of eighty-five and eighty-one years respectively. The prisoner was proved to have purchased at different times an ounce and half an ounce of sugar of lead, and to have added a white powder to the medicine of Mrs. Tregillis. The illness of the latter extended from about August 23 to October 23—a period of two months. It is difficult to say when the first dose could have been given, but it was probably some time between August 13 and 23, while the administration, without doubt, ceased on or before October 6, for on that date different nursing arrangements were made. The symptoms observed were nausea, vomiting, pain in the pit of the stomach, burning in the throat, very dark teeth, a blue line round the gums, and slight jaundice. There was great muscular weakness, with trembling of the hands, and a week before death there was paralysis of the right side.

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* The gate-keeper of a graveyard at Bordeaux continually used the remnants of crosses, covered with lead paint, to replenish his fire; the chimney smoked; gradually paralysis of the extensors of the wrist developed itself, and he suffered from colic and other signs of lead poisoning.—Marmisse. *Gaz. des Hôpit.* No. 25, 1866.

Lead was discovered in most of the viscera, which were in great part normal, but the kidneys were wasted, and the mucous membrane blackened. The actual quantity of lead recovered by analysis was small—viz., 16·2 grms. (¼ grain) from the liver; from 8 ounces of brain, 3·2 mgrms. ($\frac{1}{20}$ grain); from half of the stomach, 16·2 mgrms. (¼ grain); and from the spleen, the kidneys, and the lungs, small quantities. It is, therefore, probable that, if the whole body had been operated upon, the yield would have been more than ·15 grm. (a little over 2 grains); but then, it must be remembered that the deceased lived, at least, seventeen days after the last dose.

Post-mortem Appearances.—In acute cases of poisoning by the acetate, there may sometimes be found a slight inflammatory appearance of the mucous membrane of the stomach and intestines. Orfila considers that streaks of white points adherent to the mucous membrane were pathognomonic; but there have been several cases in which only negative or doubtful signs of inflammatory or other action have presented themselves. As a rule, no unabsorbed poison will be found in the stomach; the case related by Christison, in which a person died on the third day after taking at a single dose some large quantity of acetate of lead; and at the autopsy a fluid was obtained from the stomach, which had a sweet metallic taste, on evaporation smelt of acetic acid, and from which metallic lead was obtained—is so very extraordinary in every respect, that its entire accuracy is to be questioned. In death from chronic lead poisoning, there is but little that can be called diagnostic; a granular condition of the kidneys and all the pathological changes dependent on such a condition, are most frequently seen. If the patient has suffered from colic, a constriction of portions of the intestine has been noticed; also, in cases in which there has been long-standing paralysis of groups of muscles, these muscles are wasted, and possibly degenerated. In instances, again, in which lead has induced gout, the pathological changes dependent upon gout will be prominent. The blue line around the gums, and sometimes a coloration by sulphide of lead of portions of the intestines, may help a proper interpretation of the appearances seen after death; but all who have given any attention to the subject will agree that, simply from pathological evidence, it is impossible to diagnose chronic lead poisoning.

Physiological Action of Lead.—The action of lead is still obscure, but it is considered to have an effect mainly on the nervous centres. The paralysed muscles respond to the direct current, but not to the induced, leading to the suspicion that the intramuscular terminations of the nerves are paralysed, but that the muscular substance itself is unattacked. On the other hand, the restriction of the action to groups of muscles, supports the theory of central action.

The lead colic is due to a true spasmodic constriction of the bowel, the exciting cause of which lies in the walls of the bowel itself; the relief given by pressure is explained by the pressure causing an anæmia of the intestinal walls, and thus lessening their sensibility. The slowing of the pulse produced by small doses is explained as due to a stimulation of the inhibitory nerves; and, lastly, many nervous phenomena, such as epilepsy, &c., are in part due to imperfect elimination of the urinary excreta, causing similar conditions to those observed in uræmia.

Elimination of Lead.—When a large dose of acetate or carbonate is taken, part is transformed into more or less insoluble compounds—some organic, others inorganic; so that a great portion is not absorbed into the body at all, but passes into the intestines, where, meeting with hydric sulphide, part is changed into sulphide, colouring the aloine evacuations black. Some of the lead which is absorbed is excreted by the kidneys, but the search often yields only traces. Thudichum[*] states that in fourteen cases of lead poisoning, in two only was obtained a weighable quantity from a day's urine; in the remaining twelve lead was detected, but only by the brownish colour produced in an acid solution of the ash by hydric sulphide.

The elimination of lead by the kidneys is favoured by certain medicines, such, for example, as potassic iodide. Annuschat found in dogs poisoned by lead from 3·8 to 4·1 mgrms. in 100 cc.; but, after doses of potassic iodide, the content of lead rose to 6·9 and even to 14 mgrms.

Fatal Dose—(*a.*) *Sugar of Lead.*—It may almost be said that it is impossible to destroy human life with any single dose likely to be taken or administered. In three cases an ounce (28·3 grms.) has been taken without fatal result. Although it must be allowed that repeated moderate doses, extending over some time, are more dangerous to health and life than a single large dose, yet there seems to be in some individuals a great tolerance of lead. Christison has given ·18 grm. in divided doses daily for a long time without any bad effect, save the production of a slight colic. Swieten as also given daily 3·9 grms. (60 grains) in ten days without observing toxic effects. That, in other cases, less than a grain per gallon of some lead compound dissolved in drinking water, or in some way introduced into the economy, causes serious illness, is most inexplicable.

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[*] *Pathology of the Urine*, p. 550.

(*b.*) *The Basic Acetate* in solution is more poisonous apparently than the acetate—60 cc. (1½ drms.) have caused serious symptoms.

(*c.*) *The Carbonate of Lead.*—Doses of anything like 28 grms. (an ounce) would probably be very dangerous to an adult; the only case of death on record is that of a child who took some unknown quantity, probably from the description of the size of the lump, about 10 grms. (2½ drms.).

Antidotes and Treatment.—Soluble sulphates (especially magnesic sulphate) have been given largely in both acute and chronic cases; in the acute it stands to reason that it is well to ensure the presence of plenty of sulphates in the stomach and intestines, in order to form the sparingly soluble lead sulphate, should any residue remain; but to expect this double decomposition to go on in the blood and tissues is not based upon sound observation. The chronic lead poisoning is best treated by removal from the source of mischief, the administration of large quantities of distilled water, and medicinal doses of potassic iodide.

Localisation of Lead.—In a dog, which was killed by chronic lead poisoning, Heubel found in the bones ·02 to ·03 per cent. of lead; in the kidneys, ·01 to ·02; liver, ·01 to ·03; brain, ·004 to ·01; muscles, ·001 to ·002; in the intestines traces ·002; in the spleen, the blood, and the bile, he also only found traces. If, however, the percentage be calculated on the dry substance, they would come out somewhat as follows:—

Liver,	·03 to ·10 per cent.
Kidney,	·03 to ·07 ,,
Brain,	·02 to ·05 ,,
Bones,	·01 to ·04 ,,
Muscles,	·004 to ·008 ,,

It is of no value to search the blood for lead, for, although Tiedemann, Gmelin, Lassaigne, Chevallier, and others have frequently done so, only traces have been found. It nevertheless is taken up by the blood, and forms with organic bodies compounds soluble with difficulty.

Without going so far as to say that lead is a natural constituent of the body, it is certain that it may be frequently met with in persons who have been apparently perfectly healthy, and quite free from all symptoms of lead poisoning. Legrip found in the liver and spleen of a healthy person, 5·4 mgrms. of lead oxide in every kilogram; Oidtmann, in the liver of a man fifty-six years of age, 1 mgrm. of lead oxide per kilogram, and in the spleen 3 mgrms. per kilogram. Hence, the analyst, in searching for poison must be very careful in his conclusions. Grave and serious errors may also arise from complications; suppose, *e.g.*, that a deceased person previous to death had partaken of game, and inadvertently swallowed a shot—if the analyst had not carefully searched the contents of the stomach for *solid* bodies, but merely treated them at once with acid solvents, he would naturally get very decided lead reactions, and would possibly conclude, and give evidence to the effect, that a poisonous soluble salt of lead had been administered shortly before death.

Detection and Estimation of Lead.—A great number of fluids (such as beer, wines, vinegar, water, &c.), if they contain anything like the amount of one-tenth of a milligramme in 100 cc. will give a very marked dark colour with SH_2. It is, however, usually safest in the first place to concentrate the liquid, to add an acid, and deposit the lead on platinum, in the way to be shortly described. Nearly all the lead from oils and fatty matter may be dissolved out by shaking up the fat with dilute nitric acid; if necessary, the fat should previously be melted.

If (in the usual course of routine research) a hydrochloric acid solution is obtained from the treatment or destruction of organic substances by that agent, and lead sulphide (mixed possibly with other sulphides) is filtered off, any arsenical sulphide may first be extracted from the filter by ammonia, and any antimonious sulphide by sodic sulphide; then the sulphide may be extracted by warm hydrochloric acid, which will leave undissolved such sulphides as those of copper and mercury. On diluting the liquid, and filtration at a boiling temperature, crystals of lead chloride will be deposited on cooling.

If, however, organic matters are *specially* searched for lead, hydrochloric acid is not the best solvent, but nitric should always be preferred; and if there is reason to think that the lead exists in the form of sulphate, then the proper solvent is either the acetate of the tartrate of ammonia; but, in either case, the solution should contain an excess of ammonia. It must, however, be remembered that organic matters retain lead with great tenacity, and that in all cases where it can with any convenience be effected, the substances should be not only carbonised, but burnt to an ash; for Boucher* has shown that carbon retains lead, and that the lead in carbon resists to a considerable extent the action of solvents.

In the case of sulphate of lead, which may be always produced in an ash from organic substances by previous treatment with sufficient sulphuric acid, a very excellent method of identification is to convert it into sugar of lead. To do this, it is merely necessary to boil it with carbonate of ammonia, which changes it into carbonate of lead; treatment with acetic acid will now give the acetate; the solution may (if the lead is in very small quantity) be concentrated in a watch-glass, a drop evaporated to dryness on a circle of thin microscopic glass, and the crystals

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Ann. d'Hygiène, t. xli.

examined by the microscope; the same film next exposed to the fumes of SH_2, which will blacken it; and lastly, the solution (which should be sweet) tasted. A crystalline substance, possessing a sweet taste, and blackening when exposed to SH_2, can under the circumstances, be no other substance than acetate of lead.

If the analyst does not care for this method, there is room for choice. A solution containing lead can be converted into sulphide; in this case it is, however, absolutely necessary that there should be no great excess of acid, since as little as 2·5 per cent. of free hydrochloric acid will prevent all the lead going down. On obtaining the sulphide, the latter, as already described, can be converted into chloride by hydrochloric acid, and the crystalline chloride is extremely characteristic.

From the solution of the chloride the metal may be obtained in a solid state by inserting a piece of zinc in the solution contained in a crucible; the lead will be deposited gradually, and can be then collected, washed, and finally fused into a little globule on charcoal. A lead bead flattens easily when hit with a hammer, and makes a mark on paper. Solutions of the chloride also give a heavy precipitate of lead sulphate, when treated with a solution of sodic sulphate.

When lead is in very minute quantity, an electrolytic method is generally preferable; the lead is precipitated on platinum by using exactly the same apparatus as in Bloxam's test, described at p. 506; the liquid to be tested being placed in the inner cell, the lead film may now be identified, dissolved in nitric acid, and estimated by a colorimetric process. For the estimation of the minute fractions of a grain by a colour method, it is merely necessary to have a very dilute solution of acetate of lead, to add a known volume of SH_2 water to the liquid to be tested in a Nessler cylinder, noting the colour, and add to another a known quantity of the standard lead solution and the same quantity of SH_2 as was added to the first.

The process has an advantage which is great, *viz.*, that it either detects copper or proves its absence at the same time, and there are few cases in which the analyst does not look for copper as well as for lead. Lead, if in sufficient quantity, may be most conveniently estimated as oxide, sulphate, or chloride; the chief properties of these substances have been already described.

2. COPPER.

Copper, Cu = 63·5; specific gravity, from 8·921 to 8·952; fusing point, ·1091° (1996°F.). Copper in analysis occurs either as a film or coating on such metals as platinum, iron, &c., or in a state of fine division; or, finally, as a bead. In thin films, copper has a yellowish or a yellowish-red colour; it dissolves readily in nitric, slowly in hydrochloric acid. If air be excluded, hydrochloric acid fails to dissolve copper, and the same remark applies to ammonia; but, if there be free access of air, ammonia also acts as a slow solvent. Metallic copper in a fine state of division can be fused at a white heat to a bright bluish-green globule, which, on cooling, is covered with black oxide.

Cupric Oxide ($CuO = 79·5$; specific gravity, 6·5; composition in 100 parts, Cu 79·85, O 20·15) is a brownish-black powder, which remains in the absence of reducing gases unaltered at a red heat. It is nearly insoluble in water, but soluble in ClH, NO_3H, &c.; it is hygroscopic, and, as every one who has made a combustion knows, is readily reduced by ignition with charcoal in the presence of reducing gases.

Cupric Sulphide, $CuS = 95·5$, produced in the wet way, is a brownish powder so insoluble in water that, according to Fresenius, 950,000 parts of water are required to dissolve one part. It is not quite insoluble in ClH, and dissolves readily in nitric acid with separation of sulphur. By ignition in a stream of H_2, it may be converted into the subsulphide of copper. It must always be washed by SH_2 water.

Solubility of Copper in Water and Various Fluids.—The solubility of copper in water and saline solutions has been very carefully studied by Carnelley.[*] Distilled water exerts some solvent action, the amount varying, as might be expected, according to the time of exposure, the amount of surface exposed, the quantity of water acting upon the copper, &c. It would appear that under favourable circumstances, 100 cc. of distilled water may dissolve ·3 mgrm. of copper (·2 grain per gallon).

With regard to salts, those of ammonium exert a solvent action on copper more decided than that of any others known. With the others, however, the nature of the base exerts little influence, the action of the salt depending chiefly on the nature of its acid radical. Thus, beginning with the least effective, the following is the order of dissolving strength:—Nitrates, sulphates, carbonates, and chlorides. It will then at once be evident that a water, contaminated by sewage, and therefore containing plenty of ammonia and chlorides, might exert a very considerable solvent action on copper.

Almost all the oils and fats, as well as syrups, dissolve small quantities of copper; hence its frequent presence in articles of food cooked or prepared in copper vessels. In the very elaborate and careful experiments of Mr. W. Thompson,[†] the only oils which took up no copper, when digested on copper foil, were English neats'-foot oil, tallow oil, one sample of olive oil, palm-nut oil, common tallow oil, and white oil, which was protected from the air by a thick coating of oxidised oil on its surface.

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[*] *Journ. Chem. Soc.*, 1876, vol. ii., p. 4.

[†] Action of Fatty Oils on Metallic Copper," *Chem. News*, vol. xxxiv., pp. 176, 200, 313.

Copper as a Normal Constituent of Animal, Vegetable, and other Matters.—Copper is very widely distributed throughout the mineral, animal, and vegetable kingdoms. Besides, being present in numerous minerals and earths, it is often found in spring and river water, either from the solvent action of the water itself, or from pollution from copper mines or manufactories in which the metal is used.

In the animal kingdom it is a constant and natural constituent of the blood of the cephalopods, crustacea, gasteropods, and cephalophora, and is nearly always present in the liver and kidneys of domestic animals, as well as in men. Dr. Dupré [*] found ·035 to ·029 grain (1·8 to 2 mgrms.) in human livers, or about one part in 500,000. Bergeron and L. L. Hote's researches on fourteen bodies, specially examined for copper, fully substantiate those of Dr. Dupré; in twelve, the copper was found in quantities of from ·7 to 1·5 mgrm.; in the remaining two the amount of copper was very minute, and was not estimated.[†] Copper is also found normally in the kidneys, and Dupré [‡] detected in human kidneys about one in 100,000 parts; it is also found in the bile, and in minute traces in the blood.[§]

In the kidneys and livers of the ruminants copper may always be found, a sheep's liver containing about one part in 20,000.[‖] Church found copper in the feathers of the wings of the turaco; Melopsitt in the feathers of a paraquet (*Melopsittneus undulatus*).[¶]

In wheat (and therefore in bread), in barley, mangel-wurzel, swedes (and in both the root and leaf of turnip), as well as in most other vegetables, copper in very minute traces may be detected. Of the different vegetables specified, Dr. Dupré found, as a maximum, one part of oxide of copper in 240,000 parts of wheat; and, as a minimum, one part of oxide of copper in 4,375,000 of turnip root.[**]

Copper in Articles of Food and Drink.—Copper as an impurity, or an adulterant, is found in a great variety of articles of food and drink. It has been discovered in aërated waters, its presence being due to the use of copper cylinders, the lining tin of which had been rendered defective by corrosion.[††]

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[*] *Analyst*, No. 13, 1877.

[†] *Compt. Rendus.*, vol. lxxx., p. 268.

[‡] *Op. Cit.*

[§] Hoppe-Seyler: *Handbuch der Physiologisch. Analyse*, p. 415.

[‖] Dupré, *Op. cit.*

[¶] *Chem. News.* xxviii. 312.

[**] Dupré, *Op. cit.* Sarzeau has found copper in about 200 vegetables.

[††] "On the Presence of Lead and Copper in Aërated Waters," by Dr. James Milne.—*Chem. News*, xxxi., p. 77.

Accidents may also occur from the use of copper boilers. Mr. W. Thompson found in one case[*] no less than 3·575 grains in a gallon (51 mgrms. per litre) in water drawn from a kitchen boiler.

At Roubaix, in France, sulphide of copper had been deposited on the roof, as a consequence of the use of copper flues; the sulphide was changed into sulphate by the action of the air, and washed by the rain into the water-tank.[†]

That preserved vegetables are made of a bright and attractive green colour by impregnation with copper, from the deliberate use of copper vessels for this purpose, is a fact long known. Green peas especially have been coloured in this way, and a number of convictions for this offence have taken place in England.

In 1877, several cases were heard at the Marlborough Police Court, under the Sale of Food and Drugs Act, the charge being the addition of copper to peas; in a particular instance, the pound tin of preserved peas was found to contain ·088 copper, equal to 2½ grains of copper sulphate. There was a considerable amount of scientific evidence offered, one of the experts (Dr. Guy) declaring his conviction that copper salts were more injurious than those of lead; all agreed that the amount of copper found was beyond that which could be naturally present in any vegetable.[‡]

At the Liverpool Police Court, a firm was prosecuted for selling peas containing copper equal to 2½ grains of sulphate to the pound tin.[§]

A Liverpool grocer was fined 20s. and costs for selling peas containing copper equal to 2·6 grains of the sulphate to the pound.[‖]

At Bradford, vendors have been fined for selling coppered peas, the metal equalling from 1½ to 2 grains to the pound.[¶]

Copper may be found in spirits owing to the use of copper condensers, a remark which applies also to the essential oils, such as *oleum cajepute menthæ*, &c.[**] In France it has been added fraudulently to absinthe, to improve its colour.[††] Green sweetmeats, green toys, green papers, have all been found to contain definite compounds of copper to a dangerous extent.

Preparations of Copper used in Medicine and the Arts.

(1.) *Medicinal Preparations:—*

Sulphate of Copper, Cupri Sulphas, $CuSO_4 5H_2O$. This well-known salt is very soluble in water, reddens litmus, and is slightly efflorescent; its solution responds to all the usual tests for copper and sulphuric acid. A watery solution of the salt to which twice its volume of a solution of chlorine has been added, gives, when treated with ammonia in excess, a clear sapphire-blue solution, leaving nothing undissolved, and thus showing the absence of iron. Besides iron, sulphate of copper has been found to contain zincic sulphate.

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[*] *Chem. News*, xxxi., No. 801.

[†] Author's *Dictionary of Hygiène*, p. 167.

[‡] *Analyst*, 1877, p. 216.

[§] *Sanitary Record*, vj., p. 335.

[‖] *Sanitary Record*, vj., p. 351.

[¶] *Ibid.*, vij.. p. 63.

[**] According to Eulenberg (*Gewerbe Hygiène*, p. 716), *Oleum cajepute, Menth pip., Meliss Tæanacetti*, &c., are almost always contaminated with copper.

[††] Tardieu : *Étude Méd. Lég. sur l'Empoisonnement.*

Cuprum Aluminatum.—A preparation called cuprum aluminatum (*Pierre divine*) is in use in France and Germany as a medicine. It is composed of 16 parts cupric sulphate, 16 potassic nitrate, 16 alum, and 5 camphor.

Regular and irregular medical practitioners, veterinary surgeons, farriers, and grooms, all use sulphate of copper (bluestone) as an application to wounds. Copper as an *internal* remedy, is not in favour either with quacks or vendors of patent medicines. The writer has not yet found any patent pill or liquid containing it.

(2.) *Copper in the Arts*—Copper is used very extensively in the arts; it enters into the composition of a number of alloys, is one of the chief constituents of the common bronzing powders, is contained in many of the lilac and purple fires of the pyrotechnist, and in a great variety of pigments. The last-mentioned, being of special importance, will be briefly described :—

Pigments :—

Schweinfurt and Scheele's Green[*] are respectively the aceto-arsenite and the arsenite of copper.—(See article "Arsenic.")

Brighton Green is a mixture of impure acetate of copper and chalk.

Brunswick Green, originally a crude chloride of copper, is now generally a mixture of carbonate of copper and chalk or alumina.

Mountain Green, or Mineral Green, is the native green carbonate of copper, either with or without a little orpiment.

Neuwieder Green is either the same as mountain green, or Schweinfurt green, mixed with gypsum or sulphate of baryta.

Green Verdites is a mixture of oxide and carbonate of copper with chalk.

Verdigris is an acetate of copper, or a mixture of acetates. Its formula is usually represented as $(C_2H_3O_2)CuO$. It is much used in the arts, and to some extent as an external application in medicine. Its most frequent impurities or adulterations are chalk and sulphate of copper.

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[*] The synonyms for Schweinfurt green are extremely numerous :—Mitic green, Viennic green, imperial green, emerald green, are the principal terms in actual use.

Dose—Medicinal Dose of Copper.—Since sulphate of copper is practically the only salt administered internally, the dose is generally expressed as so many grains of sulphate. This salt is given in quantities of from ·016 to ·129 grm. (¼ to 2 grains) as an astringent or tonic; as an emetic, from ·324 to ·648 grm. (5 to 10 grains).

The sulphate of copper is given to horses and cattle in such large doses as from 30 up to 120 grains (1·9 to 7·7 grms.); to sheep, from 1·3 to 2·6 grms. (20 to 40 grains); rabbits, ·0648 to ·1296 grm. (1 to 2 grains).

Poisonous Dose.—A dose of 7·7 grms. of sulphate of copper (120 grains) has caused very serious symptoms.* A woman died in seventy-two hours, after taking 27 grms. (7 drms.) of sulphate of copper mixed with 11·6 grms. (3 drms.) of sulphide of iron. 56·6 grms. (2 ozs.) of the acetate of copper have caused death in three days; 14·17 grms. (½ oz.) in sixty hours.†

Effects of Soluble Copper Salts on Animals.—Harnack has made some experiments on animals with an alkaline tartrate of copper, which has no local action, nor does it precipitate albumin. ½ to ¾ mgrm. of copper oxide in this form, administered subcutaneously, was fatal to frogs, ·05 grm. to rabbits, ·4 grms. to dogs. The direct excitability of the voluntary muscles was gradually extinguished, and death took place from heart paralysis. Vomiting was only noticed when the poison was administered by the stomach. The temperature of animals poisoned by copper sinks, according to the researches of F. A. Falck, many degrees. These observations are in agreement with the effects of copper salts on man, and with the experiments of Orfila, Blake, C. Ph. Falck, and others.

Effects of Soluble Copper Salts on Man—Acute Poisoning.—Acute poisoning by salts of copper is rare; in the five years ending 1880, there were registered in England seven deaths from this cause—five were adults, two of the five were suicidal cases, and two were children. The symptoms produced by the sulphate of copper are those of a powerful irritant poison: there is immediate and violent vomiting; the vomited matters are of a greenish colour—a green distinguished from bile by the colour changing to blue on the addition of ammonia. There is pain in the stomach, and in a little time affections of the nervous system, as shown by spasms, cramps, paralysis, and even tetanus. Jaundice is a frequent symptom, if life is prolonged sufficiently to admit of its occurrence.

One of the best examples of acute poisoning by copper sulphate is recorded by Maschka.* A youth, sixteen years old, took an unknown large dose of powdered copper sulphate, mixed with water. Half a hour afterwards there was violent vomiting, and he was taken to the hospital. There was thirst, retching, constriction in the throat, a coppery tint in the mouth, and pain in the epigastrium, which was painful on pressure. The vomit was of a blue colour, and small undissolved crystals of copper sulphate were obtained from it. The patient was pale, the edges of the lips and the angles of the mouth were coloured blue, the surface of the tongue had also a blue tint, the temperature was depressed, the extremities cold, nails cyanotic, and the pulse small and quick. Several loose greenish-yellow evacuations were passed; there was no blood. The urine was scanty, but contained neither blood nor albumen. During the night the patient was very restless; the next morning he had violent headache, pain in the epigastrium, burning in the mouth and gullet, but no vomiting. The urine was scanty, contained blood, albumen, and colouring-matter from the bile. On the fourth day there was marked jaundice. The mucous membrane was very pale, the temperature low, pulse frequent, and great weakness, cardiac oppression, and restlessness were experienced. There was diarrhœa and tenesmus, the motions being streaked with blood; the urine also contained much blood. The liver was enlarged. The patient died in a state of collapse on the seventh day.

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* Taylor, *Op. cit.*

† Sonnenschein, *Op. cit.*

In 1836 a girl, sixteen months old, was given bluestone to play with, and ate an unknown quantity; a quarter of an hour afterwards the child was violently sick, vomiting a bluish-green liquid containing some pieces of sulphate of copper. Death took place in four hours, without convulsions, and without diarrhœa.

Subacetate of Copper, Subchloride, and Carbonate, all act very similarly to the sulphate when given in large doses.

Post-mortem Appearances.—In Maschka's case, the chief changes noted were in the liver, kidneys, and stomach. The substance of the liver was friable and fatty; in the gall-bladder there were but a few drops of dark tenacious bile. The kidneys were swollen, the cortical substance coloured yellow, the pyramids compressed and pale-brown. In the mucous membrane of the stomach there was an excoriation the size of a shilling, in which the epithelium was changed into a dirty brown mass, easily detached, laying bare the muscular substance beneath, but otherwise normal.

In a case of poisoning by verdigris (subacetate of copper) recorded by Orfila,† the stomach was so much inflamed and thickened that towards the pyloric end, the opening into the intestine was almost obliterated. The small intestines throughout were inflamed, and perforation had taken place, so that part of the green liquid had escaped into the abdomen. The large intestines were distended in some parts, contracted in others, and there was ulceration of the rectum. In other cases a striking discoloration of the mucous membrane, being changed by the contact of the salt to a dirty bluish-green, has been noticed, and, when present, will afford valuable indications.

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* *Wiener Med. Wochenschr.*, 1871, Nro. 26, p. 628.

† *Toxicologie*, vol. i., p. 787 (5th ed.)

Chronic Poisoning by Copper.—This has occasionally been seen among workers in copper or its salts, and also from the use of food accidentally contaminated by copper. In the symptoms there is a very great resemblance to those produced by lead. There is a green line on the margin of the gums. Dr. Clapton * found the line very distinct in a sailor and two working coppersmiths, and the two men were also seen by Dr. Taylor. Cases of chronic poisoning among coppersmiths have also been treated by Dr. Cameron,† but this symptom was not noticed. Corrigan speaks of the line round the gums, but describes it as purple-red. Metallic copper itself is not poisonous, so that the copper dust must be converted by the fluids of the body into a soluble salt, capable of being absorbed into the blood. Among workers in copper, Lancereaux ‡ has seen a black coloration of the mucous membrane of the digestive canal; its chemical characters appear to agree with those of carbon.

Small doses of the salts of copper continued for some time produce colicky pains, impairment of the digestion, diarrhœa, emaciation and often a catarrhal cough. It was the opinion of Corrigan § that the main difference between the slow action of copper and that of lead was that copper salts, more especially, exerted their effects on the functions of nutrition and assimilation, whilst lead acted energetically on the nervous system.

Detection and Estimation of Copper.—Copper may occur either in the routine process of precipitating by SH_2, or it may, as is generally the case, be searched for specially. If copper is looked for in a precipitate produced by SH_2, it is taken for granted that the precipitate has first been treated successively by carbonate of ammonia, sulphide of sodium, and hydrochloric acid; in other words, arsenic, antimony, and lead have been removed. The moist precipitate is now treated with warm nitric acid, which dissolves out copper sulphide with separation of sulphur; if there is sufficient copper, the fluid shows a blue colour, which of itself is an indication of copper being present. The further tests are—(1) Ammonia gives a deeper blue; (2) ferrocyanide of potash a brown-red colour or precipitate; (3) a few drops mixed with a solution of tartrate of soda, alkalised with sodic hydrate, and boiled with a crystal or two of grape-sugar, gives quickly a red precipitate of oxide of copper; (4) a needle or a clean iron wire, or any simple galvanic combination immersed in, or acting on, the liquid, soon becomes coated with the very characteristic reddish metallic film. Various other tests might be mentioned, but the above are ample.

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* *Med. Times and Gazette*, June, 1868, p. 658.

† *Med. Times and Gazette*, 1870, vol. 1, p. 581.

‡ "Atlas of Pathological Anatomy."

§ *Dublin Hosp. Gaz.*, Sept. 1855.

Special Examination for Copper.

(1.) *In Water and Liquids generally.*—The liquid may be concentrated, and the copper separated by electrolysis. A simple method is to place the liquid in a large platinum dish, and insert a piece of zinc, adding a sufficient quantity of ClH to dissolve the zinc entirely; the copper is found as an adherent film on the inner surface of the dish. It is neater, however, and more accurate, to connect the platinum dish with the negative plate of a battery, suspending in the liquid the positive electrode. The modifications of this method are numerous; some chemists use (especially for small quantities of copper) two small platinum electrodes, either of foil or of wire, and on obtaining the film, weigh the electrode, then dissolve the copper off by nitric acid, and re-weigh. Such solid substances as peas are conveniently mashed up into a paste with water and ClH; an aliquot part is carefully weighed and put in a platinum dish, connected, as before described, with a battery; at the end of from twelve to twenty-four hours all the copper is deposited, and the dish with its film dried and weighed. The weight of the clean dish, *minus* the coppered dish, of course equals the copper. Fat and oils are best thoroughly washed with hot acid water, which will, if properly performed, extract all the copper. By the use of separating funnels and wet filters, the fat or oil can be separated from the watery liquid.

A test has been recently proposed, which is certainly the most delicate known, $\frac{1}{100}$ of a mgrm. in solution being recognised with facility. A zinc platinum couple is made with two wires; on leaving this in an acid liquid containing a mere trace of copper, after several hours the platinum will be found discoloured. If the discoloration is from copper, on exposing the wire to hydrobromic acid fumes (easily produced from the action of potassic bromide and sulphuric acid) and bromine, the wire will become of a violet colour. This colour is easily recognised by rubbing the wire on a piece of porcelain.*.

(2.) *Animal Matters*, such as the liver, brain, spinal cord, &c., are best entirely burnt to an ash, and the copper looked for in the latter.* The same remark applies to bread and substances consisting almost entirely of starchy matters. Any injurious quantity of copper can, however, be extracted with hydrochloric acid and water; and, although this method of extraction is not quite so accurate, it is quicker.

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* *Chem. News*, Nov. 30, 1877.

Volumetric Processes for the Estimation of Copper.—A number of volumetric processes have been devised for the estimation of copper, but for the purposes of this work it is unnecessary to detail them. When copper is in too small a quantity to be weighed, it may then be estimated by a colorimetric process.

One of the best of these is based upon the brown colour which ferrocyanide of potash produces in very dilute solutions of copper. A standard copper solution is obtained by dissolving sulphate of copper in a litre of water, so that each cc. contains 0·1 mgrm. Cu., and a solution of ferrocyanide of potash in water is prepared, strength 4 per cent. It is also convenient to have a solution of nitrate of ammonia, which is found to render the reaction much more delicate.

The further details of the process are precisely on the same principles as the well-known colorimetric method of estimating ammonia by Nessler's solution.

3. BISMUTH.

Bismuth, Bi = 210; specific gravity, 9·799; fusing point, 264° (507·2°F.) Bismuth, as obtained in the course of analysis, is either a black metallic powder or a bead extremely brittle, and of a reddish-white colour. The compounds which it will be necessary to notice briefly, will be the teroxide and the tersulphide.

The Teroxide of Bismuth ($Bi_2O_3 = 468$; specific gravity, 8·211; Bi 89·64 per cent., O 10·36 per cent.), as prepared by igniting the carbonate or nitrate, is a pale lemon-coloured powder, which can be fused without loss of weight, but is reduced in charcoal, or in a stream of carbon dioxide, to the metallic state. It is also reduced by fusion with cyanide of potassium, or by ignition with chloride of ammonium.

The Sulphide of Bismuth ($Bi_2S_3 = 516$; Bi 81·25 per cent., S 18·75 per cent.), occurs in the course of analysis as a brownish-black or quite black precipitate, insoluble in water, dilute acids, alkalies, alkaline sulphides, sulphate of soda, and cyanide of potassium, but dissolving in moderately concentrated nitric acid, with separation of sulphur. It conually increases in weight when dried in the ordinary way, and is completely reduced when fused with cyanide of potassium.

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* In the exhumation of long buried bodies, it may be necessary to know the composition of the soil. Sonnenschein mentions a skull, now in the museum at Madrid, which was dug out of an old Roman mine, and is quite green from copper compounds.—Sonnenschein's *Handbuch*, p. 83.

Preparations of Bismuth used in Medicine and the Arts.

(1.) *Pharmaceutical Preparations :—*

Bismuthi Subnitras (Subnitrate of Bismuth, $BiNO_4H_2O$). A heavy white powder insoluble in water, and responding to the usual tests for bismuth and nitric acid. The percentage of bismuth in this preparation often varies within somewhat wide limits, for there are at least two nitrates in commerce, the one containing 79·4 per cent. of bismuth oxide, the other 76·48 per cent.

The principal impurities to be looked for are—ammonia,* carbonate of lead, arsenic, chlorine, and sodium salts. The first is easily detected by distilling with potash, and estimating the NH_3 by titration, or, if in small amount, by colorimetric methods; carbonate of lead, by effervescence with nitric and precipitation by sulphuric acids; arsenic, by Davy's test (see p. 510); chlorine, by nitrate of silver; and sodium salts, by boiling the bismuth with water, filtering, evaporating down to dryness, and examining the residue.

Tellurium has recently been suspected in preparations of bismuth; the evidence on the point, however, is not of an analytical character, but is based upon the observation that some persons, after taking certain bismuth preparations, have suffered from fœtid breath.† Sir J. Simpson records a case in which a divinity student inadvertently swallowed a dose of tellurium, which was followed by the evolution of such a persistent odour, that for the remainder of the session the patient had to sit apart from his fellow-students.

Bismuth Lozenges, Trochisci Bismuthi, are composed of subnitrate of bismuth, carbonate of magnesia, precipitated carbonate of lime, sugar, and gum, mixed with rose water. Each lozenge should contain ·13 grm. (2 grains) of nitrate of bismuth.

Solution of Citrate of Bismuth and Ammonia, Liquor bismuthi et Ammoniæ citratis, a colourless, neutral, or slightly alkaline fluid; specific gravity, 1·122; responding to the tests for bismuth and ammonia.

The probable impurities are the same as those in the subnitrate, and lead should specially be searched for, because so frequently contained in citric acid.

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* Ammonia is, perhaps, formed in the preparation of bismuth as follows :— $2Bi_2+15NO_3H=3NO_34Bi+6OH_2+NH_3+N_2O_3$.—W. G. Piper, *Pharm. Journ.*, April 21, p. 77.

† *Pharm. Journ.* (3). No. 287, Dict. 21, 76.

Carbonate of Bismuth, Bismuthi carbonas, $2(Bi_2CO_3)H_2O$, a fine white powder, answering to the tests for bismuth and carbonic anhydride, and likely to contain the same impurities as the subnitrate. It ought to give 89·1 per cent. of bismuth oxide.

The Valerianate of Bismuth, Bismuthum valerianicum, a white powder, smelling strongly of valerianic acid: if dissolved in nitric or hydrochloric acids, with separation of the valerianic acid, 100 parts must contain 79 of oxide of bismuth. The valerianate of bismuth is in the German, but not in the British pharmacopœia.

*Bismuth in the Arts.**—The principal use of bismuth is in alloys and solders. The chromate is employed in calico-printing, and the subnitrate as a paint, under the name of pearl-white.

The salts of bismuth also occur in washes for the hair, and pearl-white is used as a cosmetic, but only to a small extent.

Medicinal Doses of Bismuth.—The subnitrate and carbonate are prescribed in doses from ·0648 to 1·296 grm. (1 to 20 grains); the valerianate, from ·1296 to ·648 grm. (2 to 10 grains); and the solution, from 1·7 cc. to 5·2 cc. (½ drachm to 1½ drachm).

Toxic Effects of Subnitrate of Bismuth.—The subnitrate of bismuth in a dose of 7·7 grms. (2 drms.)† has caused the death of an adult in nine days; the symptoms were those of a powerful irritant. There was a metallic taste in the mouth, burning pain in the throat, vomiting, purging, coldness of surface, and spasms of the arms and legs. A *post-mortem* examination showed inflammatory changes in the throat, gullet, wind-pipe, and throughout the intestinal canal. In a case mentioned by Dr. Traill, a man took three times the above dose in divided quantities and suffered from very similar symptoms, but recovered.

Extraction and Detection of Bismuth in Animal Matters.—Bismuth appears to be excreted principally by the bowels as sulphide of bismuth; but it has also been detected in the urine, spleen, and liver; and Lubinsky has found it in the saliva and in the epithelium of the mouth of persons taking one of its preparations. Without denying the possibility of its existing in a soluble state in the saliva, its presence in the mouth may, under such circumstances, be ascribed to the lodgment of particles of subnitrate or subcarbonate of bismuth in the interstices of the teeth, &c. It will then be evident that, if a person is supposed to have been poisoned by a large dose of bismuth, and the analyst fail to find it in the stomach, the contents of the bowels should be next examined.

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* According to Mr. Field (*Chem. News*, vol. xxxvi., p. 261), bismuth is contained in all copper coinage—from the Bactrian coins to our own; generally, in all cupreous ores except the carbonates; and in nearly all specimens of commercial copper.

† Taylor quoting from Sobernheim, p. 335.

The extraction of bismuth must be undertaken by nitric acid, and boiling for at least two hours may be necessary to dissolve it out from the tissues. Such organs as the liver and spleen are boiled in a finely divided state with a litre of dilute nitric acid (strength, 5 per cent.), for the time mentioned, filtered, and the filtrate evaporated to dryness; the remainder is then carbonised by strong nitric acid; and, finally, the charcoal is boiled with equal parts of nitric acid and water, and the whole evaporated to dryness. By this method every trace of bismuth is extracted. The dry residue may now be brought into solution, and tested for bismuth. The best solvent for the nitrate of bismuth is dilute nitric acid 50 per cent.; the dry residue is therefore dissolved in 100 or 200 cc. of the acid, and fractional parts taken for examination:—

(1.) The solution, poured into a large volume of warm distilled water, gives a crystalline precipitate of subnitrate of bismuth. The only metal giving a similar reaction is antimony, and this is excluded by the method employed.

(2.) The filtered fluid gives on addition of sodic chloride a precipitate of oxychloride. This, again, is distinguished from oxychloride of antimony by its insolubility in tartaric acid.

(3.) Any bismuth precipitate, fused with soda on charcoal, gives a brittle bead of bismuth; the coal is coated whilst warm a dark orange-yellow; on cooling, citron-yellow.

(4.) The bead may be identified by powdering it, placing it in a short subliming tube, and passing over it dry chlorine. The powder first turns black, then melts to an amber-yellow fluid, and finally, by prolonged heating, sublimes as terchloride of bismuth.

(5.) A very delicate test proposed by Abel and Field, in 1862,* specially for the detection of bismuth in copper (but by no means confined to mineral analysis), utilises the fact that, if iodide of lead be precipitated from a fluid containing the least trace of bismuth, instead of the yellow iodide the scales assume a dark orange to a crimson tint. A solution of nitrate of lead is used; to the nitric acid solution ammonia and carbonate of ammonia added; the precipitate washed, and dissolved in acetic acid; and, finally, excess of iodide of potassium added. It is said that thus so small a quantity as ·00025 grm. may be detected in copper with the greatest ease, the iodide of lead becoming dark orange; ·001 grain imparts a reddish-brown tinge, and ·01 grain a crimson.

(6.) Van Kobell's test, as modified by Hutchings,† and proposed more especially for the detection of bismuth in minerals, is capable of being applied to any solid compound suspected of containing the metal:

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* *Journ. Chem. Soc.*, 1862, vol. xiv., p. 290; *Chem. News*, vol. xxxiv., p. 261.

† *Chem. News*, vol. xxxvi., p. 240.

—A mixture of precipitated and purified cuprous, iodide, with an equal volume of flowers of sulphur, is prepared, and 2 parts of this mixture are made into a paste with 1 part of the substance, and heated on a slip of charcoal on an aluminium support by the blowpipe flame. If bismuth be present, the red bismuth iodide will sublime, and on clean aluminium is easily distinguishable.

There are many other tests, but the above are more than sufficient.

Estimation of Bismuth.—The estimation of bismuth, when in any quantity easily weighed, is, perhaps, best accomplished by fusing the sulphide, oxide, or other compound of bismuth, in a porcelain crucible with cyanide of potassium; bismuth is reduced to the metallic state, the cyanide can be dissolved out, and the metallic powder washed (first with water, lastly with spirit), dried and weighed.

Mr. Pattison Muir has shown* that bismuth may be separated from iron, aluminium, chromium, and manganese, by adding ammonia to the acid solutions of these metals.

This observation admits of many applications, and may be usefully taken advantage of in the separation of bismuth from the nitric acid solution of such animal matters as liver, &c. The acid liquid is partially neutralised by ammonia, and, on diluting with warm water containing a little sodium or ammonium chloride, the whole of the bismuth is precipitated as oxychloride, which may be collected, and fused with cyanide of potassium, as above.

If the bismuth precipitate is in small quantity, or, if a number of estimations of bismuth are to be made, it is most convenient to use a volumetric process. In the case first mentioned, the oxychloride could be dissolved in nitric acid, sodium acetate added in excess, and sufficient acetic acid to dissolve any precipitate which has been produced, and then titrated by the following method, which we also owe to Mr. Pattison Muir:—

Estimation of Bismuth by Potassium Dichromate.†—A solution of recrystallised potassium dichromate (strength, 1 per cent.) is prepared. A known weight of pure bismuthous oxide (Bi_2O_3) is dissolved in excess of nitric acid, and a solution of sodium acetate is added to this liquid until a copious white precipitate is thrown down; acetic acid is then added in quantity sufficient to dissolve the precipitate completely, and to insure that, when the liquid is made up with water to a fixed volume, no precipitate shall be formed. A certain volume of this liquid is withdrawn by means of a pipette, placed in a beaker, and heated to boiling; the potassium dichromate is then gradually run in from a burette, the liquid being boiled between each addition of the solution, until a drop of the supernatant liquid gives a faint reddish-brown coloration when spotted with silver nitrate on a white slab.

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* Pattison Muir on "Certain Bismuth Compounds."—*Journ. Chem. Soc.*, p. 7, 1876.

† *Ibid.*, vol. i., p. 659, 1879.

Another very generally applicable volumetric method for bismuth has been proposed by Mr. Muir.* This depends on the fact (observed by Sonchay and Leussen),† that normal bismuth oxalate splits up on boiling into a basic oxalate of the composition $Bi_2O_32C_2O_3+OH_2$, but slightly soluble in nitric acid. The process is performed by precipitating the bismuth by excess of oxalic acid, dissolving the precipitate (first purified from free oxalic acid) in dilute hydrochloric acid, and lastly, titrating by permanganate. The absence of free hydrochloric acid before precipitating must be insured.

4. SILVER.

Silver =108 ; specific gravity, 10·5 ; fusing point, 1023° (1873°F.) Silver, as separated in analysis, is either a very white, glittering, metallic bead, or a dull grey powder. It does not lose weight on ignition, and is soluble in dilute nitric acid.

Chloride of Silver, $AgCl = 143{\cdot}5$; specific gravity, 5·552 ; Ag 75·27 per cent., Cl 24·73 per cent., is a dense, white, curdy precipitate, when produced in the wet way. It is very insoluble in water, dilute nitric acid, and dilute sulphuric acid ; in many warm solutions (especially aqueous solutions of the chlorides generally), the alkaline and alkaline-earthy nitrates, and tartaric acid solutions, the silver is dissolved to an appreciable extent, but deposited again on diluting and cooling. The complete solvents of chloride of silver are—ammonia, cyanide of potassium, and hyposulphite of soda. Chloride of silver cannot be fused at a high heat without some slight loss by volatilisation ; on coal in the O.F., it fuses very easily to a globule. It can with soda be reduced to metal, and can also readily be reduced by ignition in a current of hydrogen, carbon oxide, or carburetted hydrogen gas.

Sulphide of Silver, $Ag_2S = 248$; specific gravity, 7·2 ; Ag 87·1 per cent., S 12·9 per cent.; when prepared in the wet way, is a black precipitate, insoluble in water, dilute acids, and alkaline sulphides. If ignited in hydrogen it may be reduced to the metallic state ; it is soluble in nitric acid, with separation of sulphur.

Preparations of Silver used in Medicine and the Arts.

(1.) *Medicinal Preparations :—*

Nitrate of Silver, $AgNO_3$; Ag 63·51 per cent., N_2O_5 36·49 per cent. This salt is either sold crystallised in colourless rhombic prisms, or in the form of small white pencils or sticks. It gives the reactions for silver and nitric acid, and stains the skin black. 100 parts dissolved in distilled water should give, with hydrochloric acid, a precipitate which, when washed and dried, weighs 83·4 parts. The silver is, however, far more quickly estimated by the blow-pipe than in the wet way. One grm. fused in a cavity on charcoal should give a little globule of metallic silver, weighing about ·6351 grm. The chief adulterations of this substance are copper, lead, and nitrate of potash. If all the silver is precipitated by hydrochloric acid, carefully filtered off, and the filtrate evaporated to dryness, any residue will denote adulteration or impurity.

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* *Ibid.*, 1877.

† *Ann. Chem. Pharm.*, vol. cv., p. 245.

Argenti Oxidum, Oxide of Silver, $Ag_2O = 232$; Ag 93·19 per cent. A dark olive-brown powder, soluble in ammonia and nitric acid. By ignition it readily yields metallic silver. The P.B. directs that 29 grains of the oxide should yield 27 of metallic silver.

Nitrate of Silver and Potash, Argentum nitricum cum kali nitrico ($AgNO_3+KNO_3$).—This preparation is contained in the German, Austrian, and Norwegian pharmacopœias. It is directed that 100 parts of the German and Austrian preparations should, on analysis, yield not less than 27 parts of chloride of silver (20·3 Ag), and the Norwegian less than 42·058 parts of chloride of silver (31·64 Ag); the first being prepared in the proportion of 1 of silver nitrate to 2 of potassic nitrate, whilst in the Norwegian equal parts are used.

(2.) *Silver in the Arts.*—The uses of the metal in coinage, articles for domestic purposes, for ornament, &c., are too well known to require enumeration. The only forms in which silver is likely to give rise to accident are the salts used in medicine, photography, in the dyeing of hair, and in the manufacture of marking inks.

Hair-dyes.—About one-half of the hair-dyes in use are made with nitrate of silver. The following are only a few of the recipes :—

Aqua Orientalis.—Grain silver 2 drms., nitric acid 1 oz., steel filings 4 drms., distilled water 1½ oz.—the whole finally made up to 3½ fluid ozs., and filtered.

Argentan Tincture.—Nitrate of silver 1 drachm, rose water 1 fluid oz., sufficient nitrate of copper to impart a greenish tint.

Eau d'Afrique.—Two solutions—one of nitrate of silver, the other of potash, containing ammonium sulphide.

The photographer uses various salts of silver, the chief of which are —the nitrate, iodide, bromide, cyanide, and chloride of silver.

Marking Inks.—Some of the more important recipes for marking ink are as follows :—

Nitrate of silver 1·0 part, hot distilled water 3·6 parts, mucilage, previously rubbed with sap-green, 1·0 part. With this is sold a "pounce," or preparation consisting of a coloured solution of sodic carbonate.

Another preparation is very similar, but with the addition of ammonia and some colouring-matter, such as indigo, syrup of buckthorn, or sap-green. A third is made with tartaric acid and nitrate of silver, dissolved in ammonia solution, and coloured.

Redwood's consists of equal parts of nitrate of silver and potassic bitartrate, dissolved in ammonia, with the addition of archil green and sugar; according to the formula, 100 parts should equal 16·6 of silver nitrate.

Soubeiran's Ink is composed of cupric nitrate 3, argentic nitrate 8, sodic carbonate 4, and the whole made up to 100 parts, in solution of ammonia. In one of Mr. Reade's inks, besides silver, an ammoniacal solution of a salt of gold is used.

Medicinal Dose of Silver Compounds.—The nitrate and the oxide of silver are given in doses from ·0162 to ·1296 grm. (¼ grain to 2 grains). Anything like ·1944 to ·2592 grm. (3 or 4 grains) would be considered a large, if not a dangerous dose; but nothing definite is known as to what would be a *poisonous* dose.

Effects of Nitrate of Silver on Animals.—Nitrate of silver is changed into chloride by the animal fluids, and also forms a compound with albumen. Silver chloride and silver albumenate are both somewhat soluble in solutions containing chlorides of the alkalies, which explains how a metallic salt, so very insoluble in water, can be absorbed by the blood.

The action of soluble salts of silver on animals has been several times investigated. There appears to be some difference between its effects on warm and cold-blooded animals. In frogs there is quickly an exaltation of the functions of the spinal cord, tetanic convulsions appear, similar to those induced by strychnine; later, there is disturbance of the respiration and cessation of voluntary motion.

The first symptoms with dogs and cats are vomiting and diarrhœa; muscular weakness, paralysis, disturbance of the respiration, and weak clonic convulsions follow. Rouget, as well as Curci, considers that the action of silver is directed to the central nervous system; there is first excitement, and then follows paralysis of the centres of respiration and movement. Death occurs through central asphyxia. According to the researches of F. A. Falck, subcutaneous injections of silver nitrate into rabbits cause a fall of temperature of 6·7° to 17·6°, the last being the greatest fall which, in his numerous researches on the effect of poisons on temperature, he has seen.

Chronic poisoning, according to the experiments of Bogoslowsky on animals, produces emaciation, fatty degeneration of the liver, kidneys, and also of the muscles—a statement confirmed by others.

Toxic Effects of Silver Nitrate in Man—(1.) *Acute Poisoning.*—This is very rare. Orfila relates an attempt at suicide; but most of the cases have been accidental, and of these, in recent times, about five are recorded, mostly children. The accident is usually due to the application of the solid nitrate to the throat, as an escharotic, the stick breaking or becoming detached, and being immediately swallowed; such an accident is related by Scattergood.* A piece of silver nitrate, ¾ inch long, slipped down the throat of a child, aged fifteen months—vomiting immediately occurred, followed by convulsions and diarrhœa; chloride of sodium was administered, but the child died in six hours. In other cases paralysis and an unconscious state have been observed.

(2.) *Chronic Poisoning.*—Salts of silver taken for a long period cause a peculiar colour of the skin, the body becomes of a greyish blue to black colour; it begins first around the nails and fingers, then patches of a similar hue appear in different parts of the body, and gradually coalesce, being most marked in those parts exposed to the light. The colour is not confined to the outer skin, but is also seen in the mucous membranes. There is also a slight inflammation of the gums, and a violet line around their edge. Ginpon observed this line after two months' treatment of a patient by silver nitrate; the whole quantity taken being 3·9 grms. (about 60 grains). The peculiar colour of the skin is only seen after large doses; after 8 grms. taken in divided doses Chaillon could not observe any change, but after 15 grms. had been taken it was evident. So also Reimer has recorded a case, in which, after a year's use of silver nitrate (total quantity, 17·4 grms.) a greyish-black colour of the face was produced, and, when nearly double the quantity had been taken, the colour had invaded the whole body.

Post-mortem Appearances.—In the acute case recorded by Scattergood, the mucous membranes of the gullet, of the great curvature of the stomach, and parts of the duodenum and jejunum were eroded, and particles of curd-like silver chloride adhered to the mucous membrane.

In the case recorded by Riemer of the long-continued use of silver nitrate, the serous and mucous membranes were coloured dark; the choroid plexus was of a blue black; the endocardium, the valves of the heart, and the aorta pale to dark grey, as well as the rest of the vessels; the colouring was confined to the intima. The liver and kidney also showed similar pigmentation. The pigment (probably metallic silver) was in the form of very fine grains, and, as regards the skin, was situate under the *Rete malpighia* in the upper layer of the corium, and also in the deeper connective tissue and in the sweat glands. Liouville has also found the kidneys of a woman similarly pigmented, who took silver nitrate daily for 270 days, in all about 7 grms., five years before her death.

Detection and Estimation of Silver.—The examination of the solid salts of silver usually met with (viz., the nitrate, bromide, iodide, cyanide and chloride) is most speedy by the dry method on charcoal; in this way in less than 120 seconds any practical chemist could identify each compound. The nitrate, bromide, iodide, and cyanide, all, if ignited on charcoal, yield buttons of metallic silver—deflagration, bromine vapours, iodine vapours, and cyanogen vapours, being the respective phenomena observed. Chloride of silver fuses to a pearl-grey, brown, or black globule on charcoal, according to its purity; but is only in the R. F. gradually reduced to metal. With soda, or fused in hydrogen or coal gas, the reduction is rapid enough.

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* *Brit. Med. Journal*, May, 1871.

Nitrate of Silver in solution might be identified by a very large number of tests, since it forms so many insoluble salts. In practice one is, however, satisfied with three tests—viz., (1) A curdy precipitate of chloride, on the addition of hydrochloric acid or alkaline chlorides, soluble only in ammonia, cyanide of potassium, or hyposulphite of soda; (2) a yellow precipitate, but little soluble in ammonia, on the addition of iodide of potassium; and (3) a blood-red precipitate on the addition of chromate of potash.

The separation of silver from the contents of the stomach is best ensured by treating it with cyanide of potassium; for, unless a very large quantity of silver nitrate has been taken, it is tolerably certain that the whole of it has passed into chloride, and will, therefore, not be attacked easily by acids. The contents of the stomach, then, or the tissues themselves, are placed in a flask and warmed for some time with cyanide of potassium, first, if necessary, adding ammonia. The fluid is separated from the solid matters by subsidence (for an alkaline fluid of this kind will scarcely filter), and then decomposed by hydrochloric acid in excess. The flask containing this fluid is put on one side in a warm place, and the clear fluid decanted from the insoluble chloride. The latter is now collected on a filter, well washed with hot water, and then dried and reduced on charcoal; or it may be put in a little porcelain crucible with a rod of zinc and a few drops of hydrochloric acid. The silver is soon deposited, and must be washed with water, then with sulphuric acid. By the aid of a wash-bottle the particles of silver are now collected on a small filter, again washed, and on the moist mass a crystal of nitrate of potash and a little carbonate of soda laid. The whole is then dried, and all the filter cut away, save the small portion containing the silver. This small portion is now heated on charcoal until a little button of pure silver is obtained, which may first be weighed, then dissolved in nitric acid, and tested by the methods detailed.

In a similar way hair, suspected of being dyed with silver, can be treated with chlorine gas, and the chloride dissolved in potassic cyanide.

Spots on linen, and, generally, very small quantities of silver may be detected by a simple galvanic process :—The substance is treated with solution of cyanide of potassium, and submitted to a weak galvanic current, using for the negative plate a slip of copper, for the positive, platinum ; the siver is deposited on the former.

5. MERCURY.

Mercury—Hg=200 ; specific gravity, 13·596 ; boiling point, 350° (662°F.). This well-known and familiar fluid metal evaporates and sublimes to a minute extent at all temperatures above 5°.

When precipitated or deposited in a finely divided state, the metal can be united into a single globule only if it is fairly pure ; very slight *fatty* impurities especially will prevent the union. It is insoluble in hydrochloric acid, soluble to a slight extent in dilute cold sulphuric acid, and completely soluble in concentrated sulphuric and in nitric acids. It combines directly with chlorine, bromine, and iodine, which, in presence of free alkali, readily dissolve it. It is unalterable at 100°, and, when exposed to a high temperature, sublimes unchanged.

Mercurous Chloride (Calomel HgCl=235·5 ; specific gravity, 7·178 ; subliming temperature, 111·6° ; Hg 84·94 per cent. ; Cl 15·06 per cent.), when prepared in the wet way is a heavy white powder, absolutely insoluble in cold, but decomposed by boiling, water. It may be converted into the mercuric chloride by chlorine water and aqua regia. Chloride of ammonium, potassium, and sodium, all decompose calomel into metallic mercury and mercuric chloride. It is easily reduced to a metal in a tube with soda, potash, or burnt magnesia.

Sulphide of Mercury (Hg_2S, Hg 86·21 per cent., S 13·79 per cent.) is a black powder, dissolving in nitromuriatic acid, but very insoluble in other acids or in water. It is also insoluble in alkaline sulphides, with the exception of potassic sulphide.

Medicinal Preparations of Mercury.—Mercury in the liquid state has been occasionally administered in constipation ; its internal use is now (or ought to be) obsolete. Gmelin has found samples contaminated with metallic bismuth—a metal which only slightly diminishes the fluidity of mercury ; the impurity may be detected by shaking the mercury in air, and thus oxidising the bismuth. Mercury may also contain various mechanical impurities, which are detected by forcing the metal by means of a vacuum pump through any dense filtering substance. Tin and zinc may be dissolved out by hydrochloric acid, and all fixed impurities (such as lead and bismuth) are at once discovered on subliming the metal.

Mercury and Chalk (*Hydrargyrum cum creta*).—Mercury, 33·33 per cent.; chalk, 66·67.

Blue Pill (*Pilula hydrargyri*).—Mercury in a finely divided state, mixed with confection of roses and liquorice root; the mercury should be in the proportion of 33·33 per cent.[*]

Mercury Plaster (*Emplastrum hydrargyri*).—Made with mercury, olive oil, sulphur, and lead plaster; it should contain Hg 33 per cent.; sulphur, 18 per cent.

Ammoniac and Mercury Plaster (*Emplastrum ammoniaci cum hydrargyro.*)—Gum, ammonia, mercury, olive oil, and sulphur; it should contain 19·8 per cent. of Hg, and ·1 per cent of sulphur.

Mercurial Ointment, Unguentum hydrargyri.—Mercury mixed with lead and suet, all three in equal weights; therefore it should contain 33·3 per cent. of mercury.

Compound Mercury, Ointment, Unguentum hydrargyri compositum.—Made with ointment of mercury, yellow wax, olive oil, and camphor; it should contain 14·3 per cent. Hg, and 11·11 per cent. of camphor.

Liniment of Mercury, Linimentum hydrargyri, is made of mercurial ointment, solution of ammonia, and liniment of camphor; it may contain about 10 per cent. of mercury.

Mercurial Suppositories, Suppositoria hydrargyri, composed of ointment of mercury, benzoated lard, white wax, and oil of theobroma.

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[*] The chemical composition of blue pill varies according to its age. Harold Senier has made a careful series of analyses, with the following result (*Pharm. Journal*, Feb. 5, 1876):—

	Age.	Metallic Mercury.	Mercuric Oxide.	Mercurous Oxide.	Ash.	Organic Matter.
1	1 hours, . .	32·49	none.	a trace.	1·20	66·31
2	3 weeks, . .	32·26	·09	·25	1·20	66·20
3	3 months, .	32·60	·24	·62	1·18	66·36
4	3 ,, . .	31·15	·44	1·60	1·12	65·69
5	6 ,, . .	32·44	·50	·80	1·70	64·56
6	14 ,, . .	29·86	·98	2·60	1·20	65·36
7	19 ,, . .	31·56	·50	2·50	1·00	64·41
8	2 years, . .	28·40	1·80	4·22	2·10	63·48
9	(?) . .	30·23	1·06	3·24	1·05	64·44

It should contain about 11·11 per cent. of Hg, and eachsuppository should weigh 15 grains.

Acetate of Mercury, Mercurous acetate, is not contained in the B. P., but is officinal on the Continent. It is a salt occurring in white micaceous scales, soluble in 133 parts of cold water, giving the reactions of acetic acid and mercury, and very readily decomposed.

Mercuric Ethyl Chloride, Hydrargyrum æthylo-chloratum, is used as a medicine on the Continent. It occurs in white, glittering, crystalline scales, which take on pressure a metallic appearance, and possess a peculiar ethereal odour; it is but little soluble in water and ether, with difficulty in cold alcohol, but copiously soluble on boiling, and depositing crystals on cooling. It sublimes at about 40° without residue; on quick heating it burns with a weak flame, developing a vapour of metallic taste and unpleasant odour. It gives no precipitate with silver nitrate, nor with albumen.

Corrosive Sublimate, Mercuric chloride, $HgCl_2=271$; Hg 73·8 per cent., Cl 26·1 per cent. In commerce this salt occurs in transparent, heavy, colourless masses, which have a crystalline fracture; if placed in the subliming cell described at p. 229, it sublimes at about 82·2° (180°F.), and melts at higher temperatures. The sublimate is generally in groups of plates drawn to a point at both ends, in crystalline needles, or in octahedra with a rectangular base. It dissolves in 16 parts of cold water and about 3 of boiling, and is very soluble in solutions of the alkaline chlorides; it dissolves also in ether, and can be, to a great extent, withdrawn from aqueous solutions by this agent. Alcohol dissolves nearly one-third its weight of the salt, and its own weight when boiling. It combines with albumen; gives when in solution a precipitate of mercuric oxide, when tested with solution of potash; a white precipitate with ammonia; a scarlet with iodide of potassium; and a black precipitate of finely divided mercury with protochloride of tin. If a crystal (when placed in the subliming cell) gives a crystalline sublimate at about the temperature mentioned, and this sublimate becomes of a red colour when treated with a droplet of iodide of potassium, it can be no other substance than corrosive sublimate.

Solution of Perchloride of Mercury, Liquor hydrargyri perchloridi, is simply 10 grains of perchloride of mercury and chloride of ammonium in a pint of water; 100 cc. therefore should contain ·114 grm. corrosive sublimate.

Yellow Mercurial Lotion, Lotio hydrargyri flava.—Perchloride of mercury 18 grains, mixed with 1 ounce of solution of lime.

Calomel, Hydrargyri subchloridum.*—The properties of calomel have been already described. It sometimes contains as an impurity corrosive sublimate, which may be dissolved out by ether. Carbonate of lead, sulphate, and carbonate of baryta, gum, and starch, are the usual adulterants mentioned. If on the application of heat calomel entirely sublimes, it must be free from the substances enumerated.

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* It would appear that in America a cosmetic is in use, consisting of calomel mixed into a paste with water.—*Vide* " A Dangerous Cosmetic," by C. H. Piesse. *Analyst* [25], 1878, p. 241.

Black Mercurial Lotion, Lotio hydrargyri nigra.—Calomel 30 grains, mixed with 10 fluid ounces of lime-water.

Compound Pill of Subchloride of Mercury—Calomel and sulphurated antimony, each 1 ounce, guiac resin 2 ounces, castor oil 1 fluid ounce. 1 grain (·0648 grm.) of calomel, and the same quantity of antimony sulphide, are contained in every 5 grains (·324 grm.) of the pill mass—*i.e.*, calomel 20 per cent.

Ointment of Subchloride of Mercury, Unguentum hydrargyri subchloridi.—Calomel mixed with lard; strength about 14·2 per cent.

White Precipitate, Hydrargyrum ammoniatum, NH_2HgCl.—A white, heavy powder, subliming by heat without residue, and insoluble in water, alcohol, and ether. With soda, it yields a metallic sublimate. When boiled with potash, ammonia is evolved, the yellow oxide of mercury formed, and chloride of potassium passes into solution. It should contain 79·5 per cent. of mercury.

The fusible white precipitate of the pharmacopœia of the Netherlands does not appear to be of constant composition, varying between 69·4 to 65·6 per cent. of mercury.* It melts on heating, and leaves as a residue chloride of sodium.

Commercial white precipitate is frequently adulterated; Barnes has found carbonates of lead and lime, the latter to the extent of nearly 2 per cent.† Calomel, according to Nickles,‡ has been substituted for white precipitate, but this was several years ago. The methods for detection are obvious.

Ointment of Ammoniated Mercury, Unguentum hydrargyri ammoniati.—62 grains of the substance mixed with an ounce of simple ointment.

Red Iodide of Mercury, Hydrargyrum iodidum rubrum, HgI_2.—A crystalline powder of a scarlet colour, becoming yellow on gentle heating. It is very insoluble in water, one part requiring from 6000 to 7000 parts; soluble in 130 parts of cold, 150 of hot alcohol; and dissolving freely in ether, or in aqueous solution of iodide of potassium.

Ointment of Red Iodide of Mercury, Unguentum hydrargyri iodidi rubri.—16 grains of the substance mixed with an ounce of simple ointment.

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* Hirsch, "*Die Prüfung der Arzeneimittel.*"

† *Proceed. Brit. Pharm. Conf.*, 1867, p. 10.

‡ *Journ. Pharm. et Chim.*, le Série, 1858, vol. viij., p. 399.

Green Iodide of Mercury, Hydrargyri iodidum viride, HgI.—A dingy, greenish-yellow powder, darkening on exposure to light, and easily decomposed into the red iodide.

Red Oxide of Mercury, Hydrargyri Oxidum rubrum, $HgO = 216$; Hg 92·12 per cent.; specific gravity, 11 to 11·3—small, red, shining, crystalline scales, very insoluble in water, requiring about 20,000 parts, entirely soluble in hydrochloric acid. By a heat below redness it may be volatilised, and at the same time decomposed into mercury and oxygen. Its principal impurity is nitric acid, readily detected by the usual tests, or by heating in a test-tube, when, if nitric acid is present, orange vapours will be evolved. Fixed red powders (such as brick-dust and minium) are detected by being left as a residue, after the application of heat sufficient to volatilise the mercury.

Sulphate of Mercury.—A white crystalline powder, decomposed by water, into the very insoluble basic salt of mercury, known as *Turbith mineral,* $HgSO_4 2HgO$.

Turbith, or Turpeth Mineral, is contained in the French pharmacopœia, $HgSO_4 2HgO$; Hg 82·4 per cent.; specific gravity 8·319 It requires for solution 2000 parts of cold, and 600 of boiling water; but dissolves with tolerable ease in hydrochloric acid.

The Sulphide of Mercury, known in commerce under the name of *Ethiops Mineral,* is officinal in France, the Netherlands, and Germany. Its properties have been already described. The German and Dutch pharmacopœias require in it 50, the French only 33⅓ per cent., of metallic mercury.

Hahneman's Soluble Mercury, Hydrargyrum solubile Hahnemanni is officinal in the Dutch pharmacopœia. As found in commerce it contains metallic mercury, nitric acid, and ammonia. The mercury should be in the proportion of 86·33 per cent., ammonia 2·44 per cent.

Crystallised Nitrate of Mercury, Hydrargyrum nitricum oxidulatum, is officinal in the pharmacopœias of Germany, Switzerland and France. The salt is in white crystals, giving the reactions of nitric acid and mercury, decomposed by the addition of water, but fully soluble in water, if first moistened with nitric acid. The formula of the neutral salt is $Hg2NO_3HgO2H_2O$, which requires 69·4 per cent. of mercury.

An *Ointment of Nitrate of Mercury, Unguentum hydrargyri nitratis* is contained in the B.P.; it is made with 4 parts of mercury, nitric acid 12, lard 15, olive oil 32.

A *Chloride of Mercury and Quinine* exists in commerce, prepared by mixing 1 part of corrosive sublimate in solution with 3 parts of quinine chloride, evaporating and crystallising.

Cyanide of Mercury, HgCy, is contained in the French pharmacopœia. It occurs in small, colourless, prismatic crystals, easily soluble in water. If to the solution chloride of tin be added, a black precipitate of reduced metal and stannous oxide is thrown down, and the odour of prussic acid is developed.

Mercuric Sulphide, Sulphide of Mercury, Cinnabar, Vermilion, is officinal in Germany, the Netherlands, and France; $HgS = 232$; specific gravity, solid, 8·2; Hg 86·21 per cent., O 13·79 per cent. For medicinal purposes it is made artificially. It is a beautiful red powder, insoluble in all alkaline and all acid liquids, with the exception of aqua regia. The solution gives the reactions of a sulphide and mercury. On heating, it must burn away entirely without residue ; adulterations or impurities are—minium, lead, copper, and other metals. The detection of minium is conveniently executed in the dry way. Pure cinnabar, when heated in a matrass, gives a black sublimate, which becomes red on friction. If minium is present, sulphide of lead remains as a residue, and may be recognised on coal ; the same remark applies to sulphide of antimony. If it be desired to take the percentage of mercury in cinnabar, equal parts of oxalate and cyanide of potassium should be well mixed with the cinnabar, and heated in the bent tube described at p. 618 ; by this means the whole of the metallic mercury is readily obtained.*

Mercury in the Arts.—The use of mercury in the arts is so extensive, that any one in analytical practice is almost certain occasionally to meet with cases of accidental poisoning, either from the vapour† or some of its combinations.

Quicksilver is used in the extraction of gold, the silvering of mirrors, the construction of barometers, and various scientific instruments and appliances ; also for the preservation of insects, and occasionally for their destruction.‡ An alloy with zinc and cadmium is employed by dentists for stopping teeth ; but there is no evidence that it has been at all injurious, the mercury, probably, being in too powerful a state of combination to be attacked by the fluids in the mouth.§ Cinnabar has also been employed to give a red colour to confections, and it may be found in tapers, cigarette papers, and other coloured articles. The nitrate of mercury in solution finds application in the colouring of horn, in the etching of metals, in the colouring of the finer sorts of wool, and in the hat manufacture.

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* Dr. Sutro has published a case (quoted by Taylor), in which the vapour of vermilion applied externally, produced poisonous symptoms ; yet, according to Pollak, the Persians inhale it medicinally, smoking it with tobacco, catechu, mucilage, &c., the only bad effect being an occasional stomatitis.—Eulenberg : "*Gewerbe Hygiène,*" p. 741.

† A singular case is cited by Tardieu (*Etude méd.-légal sur l'Empoisonnement*), in which a man, supposing he had some minerals containing gold, attempted the extraction by amalgamation with mercury. He used a portable furnace (for the purpose of volatilising the mercury) in a small room, and his wife, who assisted him, suffered from a very well-marked stomatitis and mercurial eruption.

‡ Forty-three persons were salivated from fumigating rooms with mercury for the purpose of destroying bugs (Sonnenschein's *Handbuch*, p. 96).

§ More danger is to be apprehended from the vulcanised rubber for artificial teeth ; and, according to Dr. Taylor, accidents have occurred from the use of such supports or plates.

The sulphocyanide of mercury gives, when burnt, a most abundant ash, a fact utilised in the toy known as Pharaoh's serpent; the products of combustion are mercurial vapours and sulphurous anhydride. That the substance itself is poisonous is evident from the following experiment:—·5 grm. was given to a pigeon without immediate result; but ten hours afterwards it was indisposed, refused its food, and in forty hours died without convulsions.*

Acid Solution of Nitrate of Mercury, Liquor hydrargyri nitratis acidus, a colourless, strongly acid liquid, giving the reactions for nitric acid and mercury; specific gravity, 2·246.

The more Common Patent and Quack Medicines containing Mercury.

Mordant's Norton's Drops.—This patent medicine is a mixture of the tincture of gentian and ginger, holding in solution a little bichloride of mercury, and coloured with cochineal.

Solomon's Anti-impetigines is a solution of bichloride of mercury, flavoured and coloured.

Poor Man's Friend.—An ointment of nitrate of mercury.

Brown's Lozenges.—Each lozenge contains ½ grain of calomel, and 3½ grains of resinous extract of jalap; the rest is white sugar and tragacanth.

Ching's Worm Lozenges.—Each lozenge contains 1 grain of calomel; the rest white sugar and tragacanth, with saffron as a colouring matter.

Storey's Worm Cakes.—Each cake 2 grains of calomel, 2 grains of cinnabar, 6 grains of jalap, 5 grains of ginger, and the remainder sugar and water.

Wright's Pearl Ointment is said to be made up of 8 ounces of white precipitate rubbed to a cream in 1 pint of Goulard's extract, and to the mixture is added 7 pounds of white wax and 10 pounds of olive oil.

Keyser's Pills.—The receipt for these pills is—red oxide of mercury 1½ ounce, distilled vinegar (dilute acetic acid) 1 pint; dissolve, add to the resulting solution manna 2 lbs., and triturate for a long time before the fire, until a proper consistence is attained; lastly, divide the mass into pills of 1½ grain each.

Mitchell's Pills.—Each pill contains aloes ·8 grain, rhubarb 1·6 grain, calomel ·16 grain, tartar emetic ·05 grain.

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* Eulenberg, *Op. cit.*, p. 742.

Many *Antibilious Pills* will be found to contain calomel; a few mercury in a finely divided state.

Mercury in Veterinary Medicine.—Farmers and farriers use the ointment (*blue ointment*) to a dangerous extent, as a dressing for the fly, and wholesale poisoning of sheep has been in several instances the consequence.* Ethiops mineral and Turpeth mineral are given to dogs when affected by the distemper, worms, or the mange. Mercury, however, is not very frequently given to cattle by veterinary surgeons, ruminants generally appearing rather susceptible to its poisonous effects.

Medicinal and Fatal Dose—Horses.—Cinnabar 14·2 grms. (½ oz.), calomel 14·2 grms. (½ oz.) or more, corrosive sublimate ·13 to ·38 grm. (2 to 6 grains), and as much as 1·3 grm. (20 grains) have been given in farcy.

Cattle.—Mercury with chalk 3·8 to 11·6 grms. (1 to 3 drms.), calomel 3·8 to 7·7 grms. (1 to 2 drms.); in worms, ·65 to 1·3 grm. (10 to 20 drms.) as an alterative; Ethiops mineral, 7·7 to 15·5 grms. (2 to 4 drms.).

Dogs.—Ethiops or Turpeth mineral ·13 to 1·3 grm. (2 to 20 grains), according to the size.

Fowls.—Mercury and chalk are given in fractions of a grain.

Hogs are also treated with mercury and chalk; the dose usually given does not exceed ·32 grm. (5 grains).

It may be remarked that many doses quoted appear very large; the writer cannot but consider that 20 grains of corrosive sublimate administered to a horse would be more likely to kill the animal than to cure the disease.

Man.—Corrosive sublimate has been fatal in a dose so small as ·19 grm. (3 grains); white precipitate has caused dangerous symptoms in doses of from 1·9 to 2·6 grm. (30 to 40 grains); the cyanide of mercury has killed a person in a dose of ·64 grm. (10 grains)—*Christison;* and Turpeth mineral has proved fatal in doses of 2·6 grms. (40 grains).

Other preparations of mercury have also been fatal, but a doubt has existed as to the precise quantity. Sometimes, also, there is probably a chemical change in the substance, so that it is impossible to state the fatal dose. For example, it is well known that calomel, under influence of alkaline chlorides, can be converted into the bichloride—a fact which probably explains the extensive corrosive lesions that have been found after death from large doses of calomel.

Poisoning by Mercury—Statistics.—In the Registrar-General's death returns for the five years ending 1880, it appears that in England the deaths from mercurial poisoning* were 22 males, 15 females; total 37, or about 2·3 per cent. of the total deaths from every kind of poison. Three were children, the rest adults; 17 or 46 per cent. of the cases were suicidal.

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* Twenty-five tons of blue ointment are said to have been sold to farmers by a druggist in Boston, Lincolnshire, in the course of a single year.—Taylor's "Medical Jurisprudence," vol. i., p. 279.

The effects of the different compounds of mercury may be divided into two groups, viz:—(1) Those caused by the finely divided metal and the non-corrosive compounds; (2) the effects caused by the corrosive compounds.

(1.) *Effects of Mercurial Vapour, and of the Non-Corrosive Compounds of Mercury.*

(*a*) *Vegetable Life.*—Priestly and Boussingault have shown that plants under a glass-shade in which mercury is exposed in a saucer, first exhibit black spots on the leaves; ultimately, the latter blacken entirely, and the plants die.

(*b*) *Animal Life.*—Mercury in the form of vapour is fatal to animal life, but it is only by repeated and intense application. Eulenberg† placed a rabbit under a large glass-shade, and for four days exposed it daily for two hours to the volatilisation of 2 grms. of mercury on warm sand; on the sixth and seventh day 1·5 grm. were volatilised. On the fifteenth day there was no apparent change in the aspect of the animal; 5 grms. of mercury were then heated in a retort, and the vapour blown in at intervals of ten minutes. Fourteen days afterwards the gums were reddened and swollen, and the appetite lost; the conjunctivæ were also somewhat inflamed. The following day these symptoms disappeared, and the animal remained well.

In another experiment 20 grms. of mercury were volatilised, and a rabbit exposed to the vapour under a small glass-shade. The following day the conjunctivæ were moist and reddened; two days afterwards 10 grms. of mercury were volatilised in the same way; and in two days' interval other 10 grms. were volatilised in three-quarters of an hour. There was no striking change noticeable in the condition of the animal, but within forty-eight hours it was found dead. The cause of death proved to be an extravasation of blood at the base of the brain. The bronchia were reddened throughout, and the lungs congested. Mercury, as with man is also readily absorbed by the broken or unbroken skin; hence thousands of sheep have been poisoned by the excessive and ignorant external application of mercurial ointment as a remedy against the attacks of the fly. The sheep become emanciated, refuse food, and seem to be in pain, breathing with short quick gasps.

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* The deaths are registered under the term "*Mercury*," but the majority are poisonings by "*Corrosive Sublimate.*"

† *Op. cit.*, p. 728.

In experiments on rabbits, dogs, and warm-blooded animals generally, salivation and stomatitis are found to occur as regularly as in man; so also in both paralytic and other nervous affections have been recorded.

(*c*) *Effects on Man.*—In 1810* an extraordinary accident produced, perhaps, the largest wholesale poisoning by mercurial vapour on record. The account of this is as follows:—H.M.S. *Triumph*, of seventy-four guns, arrived in the harbour of Cadiz in the month of February, 1810; and in the following March, a Spanish vessel, laden with mercury for the South American mines, having been driven on shore in a gale, was wrecked. The *Triumph* saved by her boats 130 tons of the mercury, and this was stowed on board. The mercury was first confined in bladders, the bladders again were enclosed in small barrels, and the barrels in boxes. The heat of the weather, however, was at this time considerable; and the bladders, having been wetted in the removal from the wreck, soon rotted, and mercury, to the amount of several tons, was speedily diffused as vapour through the ship, mixing more or less with the bread and the other provisions. In three weeks 200 men were affected with ptyalism, ulceration of the mouth, partial paralysis, and, in many instances, with diarrhœa. The *Triumph* was now ordered to Gibraltar, the provisions were removed, and efforts were made to cleanse the vessel. On restowing the hold, every man so employed was salivated. The effects noted were not confined to the officers and ship's company; for almost all the stock died from the fumes—mice, cats, a dog, and even a canary bird shared the same fate, though the food of the latter was kept in a bottle closely corked up. The vapour was very deleterious to those having any tendency to pulmonic affections. Three men, who had never complained before they were saturated with mercury, died of phthisis; one, who had not had any pulmonic complaint, was left behind at Gibraltar, where his illness developed into a confirmed phthisis. Two died from gangrene of the cheeks and tongue. A woman, confined to bed with a fractured limb, lost two of her teeth; and many exfoliations of the jaw took place.

Accidents from the vapour of mercury, quite independently of its application in the arts, have also occurred, some of them under curious circumstances, such, for example, is the case mentioned in the footnote to p. 573. Witness, again, a case mentioned by Seidel,† in which a female, on the advice of an old woman, inhaled for some affection or other 2·5 grains of mercury poured on red-hot coals, and died in ten days with all the symptoms of mercurial poisoning.

The metal taken in bulk into the stomach has been considered non-poisonous, and, probably, when perfectly pure, it is so; we have, however, the case of a girl who swallowed 4½ oz. by weight of the liquid metal, for the purpose of procuring abortion—this it did not effect; but, in a few days, she suffered from a trembling and shaking of the body and loss of muscular power. These symptoms continued for two months, but there was no salivation and no blue marks on the gums. This case is a rare one, and a pound or more has been taken without injury.

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* An account of the effect of mercurial vapours on the crew of His Majesty's Ship *Triumph*, in the year 1810.—*Phil. Trans.*, 113, 1823.

† Maschka's *Handbuch*, Bd. ii., 295.

Mercury in a finely-divided form, rubbed into the skin, is absorbed and all the effects of mercurialism result. This method of administering mercury for medicinal purposes has long been in use, but when the inunction is excessive, death may occur. Thus, Leiblinger records a case in which three persons were found dead in bed; the day before they had rubbed into the body, for the purpose of curing the itch, a salve containing 270 grms. of mercury finely divided.

It is difficult to say in what proportion workers in mercury, such as water-gilders, &c., suffer. According to Hirt, not only do 1·5 to 2·1 per cent. of the workmen employed in smelting mercury ores suffer acutely, but as high a proportion as 8·7 per cent are slightly affected.

The symptoms of poisoning by mercury vapour, or by the finely divided metal, are the same as those which arise from the corrosive salts, with the exception of the local action. In mild cases there is pallor, languor, and sore mouth (from slightly inflamed gums), fœtid breath, and disorder of the digestive organs. If the action is more intense, there is an inflammation of the gums and, indeed, of the whole mouth, and salivation, which is sometimes so profuse that as much as two gallons of saliva have been secreted daily. The saliva is alkaline, has a bad odour, and its specific gravity in the early stages is increased; but ultimately becomes normal on certain places—the gums are raised into slight swellings, which gradually enlarge and coalesce. The teeth that are already carious decay more rapidly; they become loose, and some may be shed; the inflammatory action may extend to the jaw, and necrosis of portions of the bone is no unusual occurrence. On recovery, the cheeks sometimes form adhesions with the gums, and cicatrices always mark the loss of substance which such an affection entails. With the stomatitis there are disturbances of the gastro-intestinal tract—nausea and vomiting, pain in the stomach, and diarrhœa alternating with constipation. Conjunctivitis is very common, both on man and animals, from exposure to mercury vapours. The further action of the metal is shown in its profound effects on the nervous system. The patient is changed in his disposition; he is excitable, nervous, or torpid; there are sleeplessness and bad dreams, and at the same time headache, noises in the ears, giddiness, faintings, &c.

Mercurial tremor* may follow, or accompany the above state, or it may be the chief and most prominent effect. It specially affects the arms, partly withdrawing the muscles from the control of the will, so that a person affected with mercurial tremor is incapacitated for following any occupation, especially those requiring a delicate and steady touch. In cases seriously affected, the tremor spreads gradually to the feet and legs, and finally the whole body may be invaded. The patient is no longer master of his muscles—the muscular system is in anarchy, each muscle aimlessly contracting and relaxing independently of the rest; the movement of the legs becomes uncertain, the speech stuttering, the facial expressions are even distorted into grimaces, and the sufferer sinks into a piteous state of helplessness. The convulsive movements generally cease during sleep. The tremors are accompanied by interference with the functions of other organs : the respiration is weakened and difficult ; dyspnœa, or an asthmatic condition results ; the pulse is small and slow ; paresis deepening into paralysis of the extremities, or of a group of muscles, follows ; and, lastly, if the condition is not alleviated, the patient becomes much emaciated and sinks from exhaustion. Pregnant women are liable to abortion, and the living infants of women suffering from tremor have also exhibited tremor of the limbs.

In the case of the "mass poisoning" on board the *Triumph,* it has been mentioned that several of the sailors became consumptive, and the same effect has been noticed among all workers in the metal ; it is now, indeed, an accepted fact that the cachexia induced by mercurialismus, produces a weak habit of body specially liable to the tuberculous infection.

The course of the poisoning is generally more rapid when it has resulted from the taking of mercury internally as a medicine than when inhaled by workers in the metal—*e.g.*, a patient suffering from mercurial tremor shown to the Medical Society by Mr. Spencer Watson in 1872, had resisted for seven years the influence of the fumes of mercury ; and then succumbed, exhibiting the usual symptoms. Idiosyncrasy plays a considerable *rôle* ; some persons (and especially those whose kidneys are diseased) bear small doses of mercury ill, and are readily salivated or affected ; this is evidently due to imperfect elimination.

Mercuric Methide—$Hg\ (CH_3)_2$.—This compound is obtained by the action of methyl iodide on sodium amalgam in the presence of acetic ether. It is a dense, stable liquid, of highly poisonous properties. In 1865, mercuric methide in course of preparation in a London laboratory, caused two cases of very serious slow poisoning.* One was that of a German, aged thirty, who was engaged in preparing this compound for three months, and during this time his sight and hearing became impaired; he was very weak, his gums were sore, and he was ultimately admitted into St. Bartholomew's Hospital, February 3rd, 1865. His urine was found to be albuminous, and his mental faculties very torpid. On the ninth he became noisy, and had to be put under mechanical restraint. On the tenth he was semi-comatose, but there was no paralysis; his breath was very offensive, his pupils dilated; at intervals he raised himself and uttered incoherent howls. There was neither sensation nor motion in the left leg, which was extended rigidly; the knee and the foot were turned slightly inward. On the fourteenth he died insensible.

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* A case of mercurial tremor (in *Bericht des K. K. Allgem. Krankenhauses zu Wien im Jahre,* 1872, Wien, 1873), is interesting, as showing the influence of pregnancy. A woman, twenty years of age, employed in making barometers, had, in 1869, mercurial tremor and salivation. During a three months' pregnancy the tremor ceased, but again appeared after she had aborted. She again became pregnant, and the tremor ceased until after her confinement in November, 1871. The tremor was so violent that the patient could not walk ; she also had stomatitis; but ultimately, by treatment with galvanism and other remedies, she recovered.

The only appearance of note seen at the autopsy was a congestion of the grey matter in the brain; the kidneys and liver were also congested, and there were ecchymoses in the kidneys.

The second case—a young man, aged twenty-three, working in the same laboratory, was admitted into the Hospital, March 28th, 1865. In the previous January he had been exposed to the vapour of mercuric methide for about a fortnight; during the illness of the other assistant he felt ill and weak, and complained of soreness of the gums and looseness of the teeth. He had also dimness of vision, pain and redness of the eyes, giddiness, nausea and vomiting—the ejected matters being greenish and watery. At the beginning of March his sight and taste became imperfect—all things tasted alike; his tongue was numb and his gums sore, he was also salivated slightly. A week before admission he lost his hearing, and first his hands and then his feet became numb; on admission his breath was very offensive, his pupils dilated; the sight impaired; he was very deaf, and his powers of speech, taste, and smell were deficient. There was anæthesia of the body, and the movement of the limbs was sluggish and difficult. He continued in the hospital for nearly a month, with but little change. On April 24th, it was noticed that he was getting thinner and slightly jaundiced; he moved his arms aimlessly in an idiotic manner, and passed his urine involuntarily. On April 27th he was more restless, and even violent, shrieking out and making a loud, incoherent noise, or laughing foolishly; he passed his motions and urine beneath him. On July 7th he was in a similar state—perfectly idiotic. He died on April 7th, 1866, about a year and three months from his first exposure to the vapour; the immediate cause of death was pneumonia. The *post-mortem* appearances of the brain and membranes differed little from the normal state; the grey matter was pink, but otherwise healthy; there was a considerable amount of cerebro-spinal fluid; the arachnoid along the longitudinal fissure was thickened; the total weight of the brain with medulla was 41 ozs. The stomach was of enormous size; the pyramids of the kidneys were congested, as was also the small intestine; the lungs showed the usual signs of pneumonia.*

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* *St. Barth. Hosp. Reports*, vol. i. 1866, p. 141.

Effects of the Corrosive Salts of Mercury.—The type of the corrosive salts is mercuric chloride, or corrosive sublimate—a compound which acts violently when administered, either externally or internally, in large doses.† If the poison has been swallowed, the symptoms come on almost immediately, and always within the first half hour; the whole duration also is rapid. In thirty-six cases collected by F. A. Falck, eleven died on the first or second day, and eleven on the fifth day; so that 61 per cent. died in five days—the remainder lived from six to twenty-six days. The shortest fatal case on record is one communicated to Dr. Taylor by Mr. Welch—in this instance the man died from an unknown quantity within half-an-hour.

In the very act of swallowing, a strong metallic taste and a painful sensation of constriction in the throat are experienced. There is a burning heat in the throat extending downwards to the stomach. All the mucous membranes with which the solution comes in contact are attacked, shrivelled and whitened; so that, on looking into the mouth, the appearance has been described as similar to that produced by the recent application of silver nitrate. The local changes may be so intense as to cause œdema of the glottis, and death through asphyxia. In a few minutes violent pain is felt in the stomach; so much so, that the sufferer is drawn together, and is in a fainting condition; but there are rare cases in which pain has been absent. There are nausea and vomiting—the ejected matters being often streaked with blood; after the vomiting there is purging; here also the motions are frequently bloody.‡ The temperature of the body sinks, the respiration is difficult, and the pulse small, frequent, and irregular. The urine is generally scanty, and sometimes completely suppressed.* Sometimes there is profuse hæmorrhage from the bowel, stomach, or other mucous membrane, and such cases are accompanied by a considerable diminution of temperature. In a case recorded by Lœwy,† after a loss of blood by vomiting and diarrhœa, the temperature sank to 33°4. The patient dies in a state of collapse, or insensibility, and death is often preceded by convulsions.

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* *St. Barth. Hosp. Reports*, vol. ii., p. 211.

† The effects on animals are similar to those on man. Richard Mead gave a dog with bread 3·8 grms. (60 grains) of corrosive sublimate:—"Within a quarter of an hour he fell into terrible convulsions, casting up frequently a viscid frothy mucous, every time more and more bloody, till, tired and spent with his hard service, he lay down quietly, as it were, to sleep, but died the next morning."

‡ The mixture of blood with the evacuations is more constantly observed in poisoning by corrosive sublimate than in poisoning by arsenic, copper, or lead.

Two remarkable cases of death from the external use of corrosive sublimate are recorded by Anderseck. An ointment, containing corrosive sublimate, was rubbed into the skin of two girls—servants, in order to cure the itch. The one, during the inunction, complained of a burning of the skin; the other also, a little while after, suffered in the same way. During the night the skin of each swelled, reddened, and became acutely painful. There were thirst and vomiting, but no diarrhœa. On the following day there was an eruption of blebs or little blisters. On the third day they had diarrhœa, tenesmus, fever, and diminution of the renal secretion; on the fourth day, fœtid breath, stomatitis, hyperæsthesia of the body, and a feeling of "pins and needles" in the hands and feet were noted. The first girl died in the middle of the fifth day, fully conscious; the other died on the sixth. So also Taylor‡ gives the case of a girl, aged nine, who died from the effects of an alcoholic solution of corrosive sublimate (strength, 80 grains to the ounce) applied to the scalp as a remedy for ringworm. The same author§ further quotes the case of two brothers who died—the one on the fifth, the other on the eleventh day, from the effects of absorbing corrosive sublimate through the unbroken skin.

The Nitrates of Mercury are poisons, but little (if at all) inferior in corrosive action to mercuric chloride. Death has resulted from both the external and internal use. Application of the nitrate as an escharotic to the *os uteri*, in one case,‖ produced all the symptoms of mercurial poisoning, but the woman recovered; in another case,¶ its use as a liniment caused death.

When taken internally, the symptoms are scarcely different from those produced by corrosive sublimate. It seems an unlikely vehicle for criminal poisoning, yet, in the case of *Reg. v. E. Smith* (Leicester Summer Assizes, 1857), a girl was proved to have put a solution of nitrate of mercury in some chamomile tea, which had been prescribed for the prosecutrix. The nauseous taste prevented a fatal dose being taken ; but the symptoms were serious.

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* In a case recorded by Dr. Wegeler (Casper's *Wochenschrift*, January 10, 1846, p. 30) a youth, aged seventeen, swallowed 11·6 grms. (3 drachms) of the poison. No pain was experienced on pressure of the abdomen; he died on the sixth day, and during the last three days of life no urine was secreted.

† *Vierteljahrsschr. für ger. Med.* 1864, vol, i., p. 187.

‡ *Op. cit.*

§ "Poisons," 1848, p. 394.

‖ *Med. Gazette*, vol. 45, p, 1,025.

¶ *Edin. Monthly Journal*, 1864, p. 167.

Mercuric Cyanide acts in a manner very similar to that of corrosive sublimate, 1·3 grm. (about 20 grains), in one case,* and in another,† half the quantity having destroyed life.

White Precipitate (ammoniated mercury), as a poison, is weak. Out of fourteen cases collected by Taylor, two only proved fatal ; one of these formed the subject of a trial for murder, (*Reg. v. Moore ;* Lewes Lent Assizes, 1860). The effects produced are vomiting, purging, &c., as in corrosive sublimate.‡ Other preparations of mercury, such as the red iodide, the persulphide, and even calomel,§ have all a more or less intense poisonous action, and have caused serious symptoms and death.

Treatment of Acute and Chronic Poisoning.—In acute poisoning, vomiting usually throws off some of the poison, if it has been swallowed; and the best treatment seems to be, to give copious albuminous drinks, such, for example, as the whites of eggs in water, milk, and the like. The vomiting may be encouraged by subcutaneous injectiyns of apomorphine. The after-treatment should be directed to eliminating the poison, which is most safely effected by very copious drinks of distilled water.—[*See Appendix.*]

The treatment of slow poisoning is mainly symptomatic ; medicinal doses of zinc phosphide seem to have done good in mercurial tremors. Potassic iodide is also supposed to assist the elimination of mercury.

Post-mortem Appearances.—The pathological effects seen after chronic poisoning are too various to be distinctive, but in acute poisoning (especially by the corrosive salts) the changes are great and striking. After rapid death from corrosive sublimate, the escharotic whitening of the mouth, throat, and gullet, already described, will be seen. The mucous membrane right throughout, from mouth to anus, is more or less affected and destroyed, according to the dose and concentration of the poison. The usual appearances in the stomach are those of intense congestion, with ecchymoses, and portions of it may be destroyed. Sometimes the coats are very much blackened ; this is probably due to a coating of sulphide of mercury.

In St. George's Hospital Museum (Ser. ix., 43, p. 337) there is a stomach, rather large, with thickened mucous coats, and having on the mucous surface a series of parallel black, or black-brown lines of deposit; it was derived from a patient who died from taking corrosive sublimate. With the severe changes mentioned, perforation is rare.* In the intestines there are found hyperæmia, extravasations, loosening of the mucous membrane, and other changes. The action is particularly intense about the cæcum and sigmoid flexure; in one case,† indeed, there was little inflammatory redness of the stomach or of the greater portion of the intestine, but the whole surface of the cæcum was of a deep black-red colour, and there were patches of sloughing in the coats. The kidneys are often swollen, congested, or inflamed; changes in the respiratory organs are not constantly seen, but in a majority of the cases there have been redness and swelling of the larynx, trachea, and bronchi, and sometimes hepatisation of smaller or larger portions of the lung.

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* *Orfila*, i., p. 735.

† Christison, p. 427.

‡ See Dr. Th. Stevenson, " Poisoning by White Precipitate."—*Guy's Hospital Reports*, vol. xix., p. 415.

§ Seidel quotes a case from Hasselt, in which a father, for the purpose of obtaining insurance money, killed his chilld by calomel.

In St. George's Hospital Museum, there are (from a patient dying in the hospital) preparations which well illustrate what pathological changes may be expected in any case surviving for a few days. The patient was Francis L——, aged 45, admitted to the hospital, February 27, 1842. He took a quantity of corrosive sublimate spread on bread and butter, was immediately sick, and was unable to take as much as he had intended. The stomach-pump and other remedies were used. On the following day his mouth was sore, and on March 1st his vision was dim; his mouth was drawn over to the right side, and he lost power over the left eyelid, but he had no pain; he passed some blood from the bowel. On the 2nd he passed much blood, and was salivated; still no pain. On March 4, on the evening of the sixth day, he expired; he was drowsy during the last day, and passed watery evacuations.

Prep. 14 a, Ser. ix., shows the pharynx, œsophagus, and tongue; there is ulceration of the tonsils, and fibrinous exudation on the gullet. The stomach (43 b. 199) shows a large dark slough, three inches from the cardiac extremity; the margin surrounding the slough is thickened, ulcerated, and irregular in shape, the submucous tissue, to some extent, being also thickened; there is fibrine in the ileum, pharynx, and part of the larynx. The action extended to the whole intestine; the rectum in prep. 145 a, 36, is seen to be thickened, and has numerous patches of effused fibrine.

It is a curious fact that the external application of corrosive sublimate causes inflammatory changes in the alimentary canal of nearly the same intensity as if the poison had been swallowed. Thus, in the case of the two girls mentioned *ante* (p. 582), there was found an intense inflammation of the stomach and intestines, the mucous tissues being scarlet-red, swollen, and with numerous extravasations.

The effects of the nitrate of mercury are similar to the preceding; in the few cases which have been recorded, there has been intense redness and inflammation of the stomach and intestines, with patches of ecchymosis. White precipitate, cyanide of mercury, mercuric iodide, and mercurous sulphide (turpeth-mineral), have all caused inflammation, more or less intense, of the intestinal tract.

Elimination of Mercury.—The question of the channels by which mercury is eliminated is of the first importance. It would appear certain that it can exist in the body for some time in an inactive state, and then, from some change, be carried into the circulation and show its effects.* Voit considers that mercury combines with the albuminous bodies, separating upon their oxidation, and then becoming free and active.†

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* There is only one case of perforation an record. † *Lancet*, 1845, p. 700.

The main channel by which absorbed mercury passes out of the body is the kidneys, whilst mercurial compounds of small solubility are in great part excreted by the bowel. A. Bynssen,‡ after experimenting with mercuric chloride (giving ·015 to ·15 grm., with a little morphine hydrochlorate), came to the conclusion that it could be detected in the urine about two hours, and in the saliva about four hours, after its administration; he considered that the elimination was finished in twenty-four hours.

From the body of a hound that, in the course of thirty-one days, took 2·789 grms. of calomel (2·368 Hg) in 87 doses, about 94 per cent. of the substance was recovered on analysis:—

	Mercurous Sulphide.
In the fæces,	2·1175
,, urine,	0·0550
,, brain, heart, lungs, spleen, pancreas, kidneys, scrotum, and penis,	0·0090
,, liver,	0·0140
,, muscles.	0·0114
	2·2069

This equals 1·9 of metallic mercury.§ Thus, of the whole 2·2 grms. of mercuric sulphide separated, over 95 per cent. was obtained from the fæces.

This case is of considerable interest, for there are recorded in toxicological treatises a few cases of undoubted mercurial poisoning in which no poison had been detected, although there was ample evidence that it had been administered by the mouth. In such cases, it is probable, that the whole length of the intestinal canal had not been examined, and the analysis failed from this cause. When (as not unfrequently happens) the mercurial poison has entered by the skin, it is evident that the most likely localities are the urine, the liver, and the kidneys.*

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* Tuson gave a mare, first, 4 grains, and afterwards 5 grains of corrosive sublimate twice a day; at the end of fourteen days, in a pint of urine no mercury was detected, but at the end of three weeks it was found.

† Voit, *Physiol. Chem. Unters.*, Augsburg, 1857.

‡ *Journal de l'Anat. et de Physiol.*, 1872, No. 5, p. 500. On the separation of mercury by the urine, *see* also Saikowsky in Virchow's *Archives*, 1866.

§ Riederer, in Buchner's *Neues Repert. f. Pharm.*, Bd. xvii. 3, 257, 1868.

In a case related by Vidal,† the *Liquor Bellostii* (or solution of mercuric nitrate) was ordered by mistake instead of a liniment. Although externally applied, it caused salivation, profuse diarrhœa, and death in nine days. The whole of the intestinal tract was found inflamed with extravasations, and mercury detected in the liver.

In any case of external application, if death ensues directly from the poison, evidence of its presence will probably be found; but too much stress must not be laid upon the detection of mercury, for, as Dr. Taylor says, "Nothing is more common than to discover traces of mercury in the stomach, bowels, liver, kidneys, or other organs of a dead body."‡

Tests for Mercury.—Mercury, in combination and in the solid form, is most readily detected by mixing the substance intimately with dry anhydrous sodic carbonate, transferring the mixture to a glass tube, sealed at one end, and applying heat. If mercury be present, a ring of minute globules condenses in the cool part of the tube. If the quantity of mercury is likely to be very minute, it is best to modify the process by using a subliming cell (p. 229), and thus obtain the sublimate on a circle of thin glass in a convenient form for microscopical examination. If there is any doubt whether the globules are those of mercury or not, this may be resolved by putting a fragment of iodine on the lower disc of the subliming cell, and then completing it by the disc which contains the sublimate (of course, the supposed mercurial surface must be undermost); on placing the cell in a warm, light place, after a time the scarlet iodide is formed and the identification is complete. Similarly, a glass tube containing an ill-defined metallic ring of mercury can be sealed or corked up with a crystal of iodine, and, after a few hours, the yellow iodide, changing to scarlet, will become apparent. There are few (if any) tests of greater delicacy than this.

Mercury in solution can be withdrawn by acidulating the liquid, and then inserting either simply a piece of gold foil, gold wire, or bright copper foil; or, else, by a galvanic arrangement, such as iron wire wound round a gold coin, or gold foil attached to a rod of zinc; or, lastly, by the aid of gold or copper electrodes in connection with a battery. By any of these methods, mercury is obtained in the metallic state, and the metal with its film can be placed in a subliming cell, and globules deposited and identified, as before described.

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* Very recently a woman died from the effects of a corrosive sublimate lotion applied by a quack to a wound in her leg. The writer found no poison in the stomach, but separated a milligramme of metallic mercury from the liver; the urine and intestines were not sent.

† *Gaz. des Hôp.*, Juillet, 1864.

‡ Taylor, "Medical Juisprudence," i., p. 288

The *Precipitating Reagents* for mercury are numerous: a solution of stannous chloride, heated with a solution of mercury, or any combination, whether soluble or insoluble, reduces it to the metallic state.

Mercurous Salts in solution yield, with potash, soda, or lime, a black precipitate of mercurous oxide. *Mercuric Salts,* a bright yellow precipitate of mercuric oxide.

Mercurous Salts yield black precipitates, with sulphides of ammonium and hydrogen. *Mercuric Salts* give a similar reaction, but, with sulphuretted hydrogen, first a whitish precipitate, passing slowly through red to black.

Mercurous Salts with solutions of the chlorides give a white precipitate of calomel; the *Mercuric Salts* yield no precipitate under similar circumstances. *Mercurous Salts* treated with iodide of potassium give a green mercurous iodide; *mercuric,* a scarlet.

The Detection of Mercury in Organic Substances and Fluids.—The galvanic process, previously described, is found in practice the best. Fluids, such as urine, must be evaporated to dryness, and then treated with hydrochloric acid. Such organs as the liver are cut up and dissolved in hydrochloric acid (1 : 4), and the strained fluid tested by electrolysis. Dr. Taylor relates how by this process distinct evidence of mercury in the liver was obtained on a piece of copper gauze, in a case where a child had been given two grains of calomel before death. "Four ounces of the liver were treated with hydrochloric acid and water, and a small piece of pure copper placed in the acid liquid while warm, and kept there for about forty-eight hours. It acquired a slight silvery lustre, and globules of mercury were obtained from it by sublimation."

In those cases where no special search is made for mercury, but an acid (hydrochloric) solution is treated with sulphuretted hydrogen, mercury is indicated by the presence of a black precipitate, which does not dissolve in warm nitric acid.

The further treatment of the black sulphide may be undertaken in two ways:—

(1.) It is collected on a porcelain dish, with the addition of a little nitric acid, and evaporated to dryness in order to destroy organic matter. Hydrochloric and a few drops of nitric acid are next added; the action is aided by a gentle heat, the solution finally evaporated to dryness on the water-bath, and the residue taken up by warm distilled water. The solution is that of a persalt of mercury, and the mercury can be separated by electrolysis, or indicated by the tests already detailed.

(2.) The other method, and the most satisfactory, is to mix the sulphide while moist with dry carbonate of soda, make it into a pellet which will easily enter a reducing or subliming tube, dry it carefully, and obtain a sublimate of metallic mercury.

A very neat method for the detection and estimation of mercury has been suggested by Ludwig:*—3 grms. of zinc dust are put in the organic liquid, which is then acidified; after agitation and time to allow all the mercury to be deposited on the zinc, the zinc dust is washed with water, with potash, and finally with alcohol and ether. It is dried and put into a combustion tube; first the zinc dust which has amalgamated with the mercury, then some asbestos; next some cupric oxide, and lastly some pure zinc dust—the combustion tube is drawn out into a thin capillary extremity, and a combustion made, when the mercury collects in the capillary part.

Estimation of Mercury.—All pharmaceutical substances containing mercury, as well as the sulphide prepared in the wet way, and minerals, are best dealt with by obtaining and weighing the metal in the solid state. The assay is very simple and easy when carried out on the method that was first, perhaps, proposed by Domeyko. A glass tube (which, should not be too thin), closed at one end, is bent, as shown in Fig. 19; the diameter should be about three lines, the length from seven to eight inches, the shorter arm not exceeding two inches. The powdered substance is mixed with two or three times its weight of litharge, and introduced into the tube at *a*. The portion of the tube containing the mercury is at first heated gently, but finally brought to a temperature sufficient to fuse the substance and soften the glass. The mercury collects in an annular film at *b* in the cooler limb, and may now, with a little management of the lamp, be concentrated in a well-defined ring; the portion of the tube containing this ring is cut off, weighed, then cleansed from mercury, and reweighed. Many of the pharmaceutical preparations do not require litharge, which is specially adapted for ores, and heating with sodic carbonate (in great excess) will suffice. Mercury mixed with organic matter must be first separated as described, by copper or gold, the silvered foil rolled up, dried, introduced into the bent tube, and simply heated without admixture with any substance; the weight may be obtained either by weighing the foil before and after the operation, or as above.

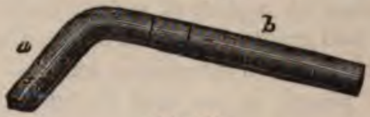

Fig. 19.

Volumetric Processes for the Estimation of Mercury.—When a great number of mercurial preparations are to be examined, a volumetric process is extremely convenient. There are several of these processes, some adapted more particularly for mercuric, and others for mercurous compounds. For mercuric, the method of Personne* is the best. The conversion of the various forms of mercury into corrosive sublimate may be effected by evaporation with aqua regia, care being taken that the bath shall not be at a boiling temperature, or there will be a slight loss.

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* *Ztg. für Physiol. Chemie.*, 1882, vol. i., p. 495.

Personne prefers to heat with caustic soda or potash, and then pass chlorine gas into the mixture ; the excess of chlorine is expelled by boiling, mercuric chloride in presence of an alkaline chloride not being volatilised at 100°. The standard solutious required for this process are—

(1.) 33·2 grms. of potash iodide in 1 litre of water, 1 cc.=0·01 grm. Hg, or 0·01355 grm. $HgCl_2$.

(2.) A solution of mercuric chloride containing 13·55 grms. to the litre, 1 cc. = 0·1 grm. Hg.

The process is founded on the fact that, if a solution of mercuric chloride be added to one of potassic iodide, in the proportion of one of the former to four of the latter, mercuric iodide is formed, and immediately dissolved, until the balance is overstepped, when the red colour is developed ; the final reaction is very sharp, and with solutions properly made is very accurate. The mercuric solution must always be added to the alkaline iodide ; a reversal of the process does not answer. It therefore follows that the solution to be tested must be made up to a definite bulk, and added to a known quantity of the potassic iodide until the red colour appears.

Mercurous Salts may be titrated with great accuracy by a decinormal solution of sodic chloride. This is added to the cold solution in very slight excess, the calomel filtered off, the filtrate neutralised by pure carbonate of soda, and the amount of sodic chloride still unused found by titration with nitrate of silver, the end reaction being indicated by chromate of potash. Several other volumetric processes are fully described in works treating upon this branch of analysis.

III.—PRECIPITATED BY HYDRIC SULPHIDE FROM A NEUTRAL SOLUTION.

ZINC—NICKEL—COBALT.

I. ZINC.

Zinc.—At. wt., 65; specific gravity, 6·8 to 7·1 ; fusing point, 412° (773° F.)—is a hard, bluish-white, brittle metal, with a crystalline fracture. Between 100° and 150° it becomes ductile, and may be easily wrought, but at a little higher temperature, it again becomes brittle, and at a bright red heat it fuses, and then volatilises, the fumes taking fire when exposed to the air. In analysis, zinc occurs either as a metallic deposit on a platinum foil or dish, as as a brittle bead, obtained by reducing a zinc compound with soda on charcoal.

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* *Compes Rendus*, lvi., 68 ; Sutton's *Vol. Anal.*, 177.

The salts of zinc to be briefly described here are the carbonate, the oxide, and the sulphide—all of which are likely to occur in the separation and estimation of zinc, and the sulphate and chloride—salts more especially found in commerce, and causing accidents from time to time.

Carbonate of Zinc, in the native form of calamine, contains, as is well known, 64·8 per cent. of oxide of zinc; but the carbonate obtained in the course of an analysis by precipitating the neutral hot solution of a soluble salt of zinc by carbonate of potash or soda, is carbonate of zinc *plus* a variable quantity of hydrated oxide of zinc. Unless the precipitation takes place at a boiling temperature, the carbonic anhydride retains a portion of the oxide of zinc in solution. By ignition of the carbonate, oxide of zinc results.

Oxide of Zinc ($ZnO = 81$; specific gravity, 5·612; Zn 80·24, O 19·76) is a white powder when cool, yellow when hot. If mixed with sufficient powdered sulphur, and ignited in a stream of hydrogen, the sulphide is produced; if ignited in the pure state in a rapid stream of hydrogen gas, metallic zinc is obtained; but, if it is only a feeble current, the oxide of zinc becomes crystalline, a portion only being reduced.

Sulphide of Zinc ($ZnS = 97$; specific gravity, 4·1; Zn 67·01, S 32·99).—The sulphide obtained by treating a neutral solution of a soluble salt of zinc by hydric sulphide, is hydrated sulphide, insoluble in water, caustic alkalies, and alkaline sulphides, but dissolving completely in nitric or in hydrochloric acid. When dry, it is a white powder, and if ignited contains some oxide of zinc. The anhydrous sulphide is produced by mixing the precipitated sulphide with sulphur, and igniting in a crucible in a stream of hydrogen gas.

Sulphate of Zinc ($ZnSO_4 7H_2O$ 161+126; specific gravity, crystals, 1·931).—This salt is officinal in all the pharmacopœias, is used in calico-printing, and is commonly known as *white vitriol*. By varying the temperature at which the crystals are allowed to be formed, it may be obtained with 6, 5, 2, or 1, atoms of water. The commercial sulphate is in crystals exactly similar to those of Epsom salts; it is slightly efflorescent, and gives the reactions of zinc and sulphuric acid.

Chloride of Zinc is obtained by dissolving zinc in hydrochloric acid, or by direct union of zinc and chlorine. Chloride of zinc is the only constituent in the well-known "Barnett's disinfectant fluid." A solution of chloride of zinc may be heated until it becomes water-free; when this takes place it still remains fluid, and makes a convenient bath, for warmth may be applied to it above 370° without its emitting fumes to inconvenience; at a red heat it distils. A concentrated solution of zinco-ammonic chloride ($2H_4NClZnCl_2$) is used for the purpose of removing the film of oxide from various metals preparatory to soldering.

Zinc in the Arts.—The use of zinc as a metal in sheeting cisterns, articles for domestic use, alloys, &c., is well known. Sulphide of zinc has lately been employed as a substitute for white lead, and may possibly supersede it. Zinc white is further employed as a pigment, and, mixed with albumen, is an agent in calico-printing; it is also used in the decoloration of glass, in the polishing of optical glasses, and in the manufacture of artificial meerschaum pipes.*

Chromate of Zinc ($ZnCrO_4$) is used in calico-printing, and there is also in commerce a basic chromate known as *zinc-yellow*. Zinc-green, or Rinman's green, is a beautiful innocuous colour, formed by igniting a mixture of dry zincic and cobaltous carbonates.

The use of zinc vessels in the preparation of foods may occasionally bring the metal under the notice of the analyst. When exposed to a moist atmosphere, zinc becomes covered with a thin film of oxide, perfectly insoluble in ordinary water; but, if the water should be charged with common salt, a considerable quantity may be dissolved. It may generally be laid down as a rule that the solvent power of water on zinc has a direct relation to the chlorides present, whilst carbonate of lime greatly diminishes this solubility.†

Milk may become contaminated by zinc; for, it is a matter of common knowledge, that milk contained in zinc vessels does not readily turn sour. This may be explained by the zinc oxide combining with the lactic acid, and forming the sparingly soluble lactate of zinc $2(C_3H_5O_3)Zn+3H_2O$, thus withdrawing the lactic acid as fast as it is formed, preventing the coagulation of the casein. With regard to this important practical subject, MM. Payne and Chevallier made several experiments on the action of brandy, wine, vinegar, olive oil, soup, milk, &c., and proved that zinc is acted on by all these, and especially by the alcoholic, acetic, and saline liquids. M. Schaufféle has repeated these experiments, and determined the amount of zinc dissolved in fifteen days by different liquids from a galvanised iron as well as a zinc vessel.

The amount found was as follows :—

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* Artificial meerschaum pipes are composed of zinc white, magnesia usta, and caseine ammonium.

† Ziurek, indeed, found in a litre of water contained in a zinc cistern no less than 1·0104 grm of zinc, and the same water showed only 0·074 grm. of common salt to the litre. *Vierteljahrsschr. für gericht. Medicin*, 1867. Bd. 6, p. 356.

	The liquid from the zinc vessel, grms. per litre.	The liquid from the galvanised iron vessel, grms. per litre.
Brandy,	0·95	0·70
Wine,	3·95	4·10
Orange-flower water,	0·50	0·75
Vinegar,	31·75	60·75
Fatty soup,	0·46	1·00
Weak soup,	0·86	1·76
Milk,	5·13	7·00
Salt water,	1·75	0·40
Seltzer water,	0·35	0·30
Distilled water,	traces.	traces.
Ordinary water,	traces.	traces.
Olive oil,	none.	none.

Effects of Zinc, as shown by Experiments on Animals.—Harnack, in experiments with sodium-zinc oxide pyrophosphate, has shown that the essential action of zinc salts is to paralyse the muscles of the body, and the heart, and, by thus affecting the circulation and respiration, to cause death; these main results have been fully confirmed by Blake, Letheby, and C. Ph. Falck. For rabbits the lethal dose is ·08 to ·09 grm. of zinc oxide, or about ·04 per kilogrm. The temperature during acute poisoning sinks notably—according to F. A. Falck's researches on rabbits, from about 7·3° to 13·0°. Zinc is eliminated mainly by the urine, and has been recognised in that fluid four to five days after the last dose. It has also been separated in small quantity from milk and the bile.

Effects of Zinc Compounds on Man—(*a.*) *Zinc Oxide.*—The poisonous action of zinc oxide is so weak that it is almost doubtful whether it should be considered a poison. Dr. Marcett has given a pound (453·6 grms.) during a month in divided doses without injury to a patient afflicted with epilepsy; and the workmen in zinc manufactories cover themselves from head to foot with the dust without very apparent bad effects. It is not, however, always innocuous, for Popoff has recorded it as the cause of headache, pain in the head, cramps in the calves of the legs, nausea, vomiting, and diarrhœa; and he also obtained zinc from the urine of those suffering in this manner.* Again, a pharmacy student† filled a laboratory with oxide of zinc vapour, and suffered from well-marked and even serious poisonous symptoms, consisting of pain in the head, vomiting, and a short fever. It must be remembered that, as the ordinary zinc of commerce is seldom free from arsenic, and some samples contain gallium, the presence of these metals may possibly have a part in the production of the symptoms described.

(*b.*) *Sulphate of Zinc*—Sulphate of zinc has been very frequently taken by accident or design, but death from it is rare. The infrequency of fatal result is due, not to any inactivity of the salt, but rather to its being almost always expelled by vomiting, which is so constant and regular an effect, that in doses of 1·3 grm. (20 grains), sulphate of zinc is often relied upon in poisoning from other substances to quickly expel the contents of the stomach. In a case reported by Dr. Gibb, an adult female swallowed 4·33 grms. (67 grains), but no vomiting occurred, and it had to be induced by other emetics; this case is unique. It is difficult to say what would be a fatal dose of zinc sulphate, but the serious symptoms caused by 28 grms. (1 ounce) in the case of a groom in the service of Dr. Mackenzie, leads to the view that, although not fatal in that particular instance, it might be in others. The man took it in mistake for Epsom salts; a few minutes after he was violently sick and purged, and was excessively prostrated, so that he had to be carried to his home; the following day he had cramps in the legs, and felt weak, but was otherwise well.

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* The so-called "zinc fever" has only been noticed in the founding of brass; it is always preceded by well-marked shivering, the other symptoms being similar to those described.

† *Rust'*[illegible]*ine*, Bd. xxi., § 563.

In a criminal case related by Tardieu and Roussin, a large dose of zinc sulphate, put into soup, caused the death of an adult woman of sixty years of age, in about thirty hours.* The symptoms were violent purging and vomiting, leading to collapse. From half of the soup a quantity of zinc oxide, equal to 1·6 grm. of zinc sulphate was separated. Zinc was also found in the stomach, liver, intestines, and spleen—(see also a case of criminal poisoning recorded by Chevallier).†

(*c.*) *Zinc Chloride*—Chloride of zinc is a powerful poison which may kill by its primary or secondary effects; its local action as a caustic is mainly to be ascribed to its intense affinity for water, dehydrating any tissue with which it comes in contact. The common use of disinfecting fluids containing zinc chloride, such as Burnett's fluid, leads to more accidents in England than any other European country. Of twenty-six cases of poisoning by this agent, twenty-four occurred in England, and only two on the Continent. Death may follow the external use of zinc chloride. Some years ago a quack at Barnstaple, Devon, applied zinc chloride to a cancerous breast; the woman died with all the general symptoms of poisoning by zinc, and that metal was found in the liver and other organs.

The symptoms observed in fatal cases of chloride of zinc poisoning are—immediate pain in the throat, and burning of the lips, tongue, &c. There is difficulty in swallowing, an increase in the secretion of saliva, vomiting of bloody matters, diarrhœa, collapse, coma, and death. In some cases, life has been prolonged for days; but, on the other hand, death has been known to occur in a few hours. In those cases in which either recovery has taken place, or in which death is delayed, nervous symptoms rarely fail to make their appearance. In a case recorded by Dr. R. Hassall, 3 ounces of Burnett's fluid were swallowed. The usual symptoms of intense gastro-intestinal irritation ensued, but there was no purging until the third day; after the lapse of a fortnight, a train of nervous symptoms set in, indicated by a complete perversion of taste and smell. In other cases, aphonia, tetanic affections of groups of muscles, with great muscular weakness and impairment of sight, have been noticed. Very large doses of zinc chloride have been recovered from—*e.g.*, a man had taken a solution equivalent to about 13 grms. (200 grains) of the solid chloride. Vomiting came on immediately, and there was collapse, but he recovered in sixteen days. On the other hand, ·38 grm. (6 grains) has destroyed life after several weeks' illness.

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* Taylor notices this case, but adds that she died in three days. This is a mistake, as the soup was taken on the 12th of June, probably at mid-day, and the woman died on the 13th, at 8 p.m.

† *Observations toxicologiques sur le zinc, Annales d'Hygiène Publique.* July, 1878, p. 153.

Post-mortem Appearances.—In poisoning by sulphate of zinc, the appearances usually seen are inflammation, more or less intense, of the mucous membrane of the stomach and bowels. In the museums of the London Hospitals, I could only find (1882) a single specimen preserved illustrating the effects of this poison. This preparation is in St. George's Hospital museum, and shows (ser. ix., 43 and 198) the stomach of a man who died from zinc sulphate, and whose case is reported in the *Lancet*, 1859. The mucous membrane is wrinkled all over like a piece of tripe; when recent it was vascular and indurated, but uniformly of a dirty grey colour; the lining membrane of the small intestine is very vascular, and in the duodenum and upper part of the jejunum, the colour is similar to that of the stomach, but in a less marked degree; the stomach and intestines are contracted.

The pathological appearances after chloride of zinc vary according to the period at which death takes place. When it has occurred within a few hours, the lining membrane of the mouth and gullet shows a marked change in texture, being white and opaque, the stomach hard and leathery, or much corrugated or ulcerated. In cases in which life has been prolonged, contractions of the gullet and stomach may occur very similar to those caused by the mineral acids, and with a similar train of symptoms. In a case which occurred under Dr. Markham's* observation, a person died ten weeks after taking the fatal dose, the first symptoms subsiding in a few days, and the secondary set of symptoms not commencing for three weeks. They then consisted mainly of vomiting, until the patient sank from exhaustion. The stomach was constricted at the pyloric end, so that it would scarcely admit a quill.

In Guy's Hospital there is a good preparation, 1799^{35}, from the case of S. R., aged twenty-two; she took a tablespoonful of Burnett's fluid, and died in about fourteen weeks. There were at first violent vomiting and purging, but she suffered little pain, and in a day or two recovered sufficiently to move about the house; but the vomiting after food continued, everything being ejected about five minutes after swallowing. Before death she suffered from pneumonia. The stomach is seen to be much contracted—five inches in length; it is ulcerated both near the pylorus and near the gullet; at the latter part, there is a pouch-like portion of the mucous membrane of the stomach adherent to the spleen, which communicates by a perforation with an abscess formed and bounded by the stomach, diaphragm, and spleen; it contained 3 oz. of dirty-looking puss. At the pylorus, in the centre, there is a second perforation, but extravasation of the contents is prevented by the adherent omentum and transverse colon. The muscular coats are thickened.

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* *Med. Times and Gazette*, June 11, 1859, p. 595.

Detection of Zinc in Organic Liquids or Solids.—In cases where the poison has been expelled from the stomach by vomiting, the muscles and bones would appear to be the best tissues to examine chemically; for Matzkewitsch investigated very carefully a dog poisoned by 100 parts of zinc, subcutaneously injected in the form of acetate, and found it distributed over the several organs of the body in the following ratios:—Muscles 60·5, bones 35·49, stomach and intestines 4·63, skin 3·70, place of injection 2·19, liver 1·75, lungs and heart 1·68, kidneys, bladder, and urine 1·14.

The only certain method of detection is to produce the sulphide of zinc, best effected by saturating a neutral or feebly acid liquid with hydric sulphide. If an organic liquid which can be easily filtered, is operated upon, it may be strongly acidulated with acetic acid, and at once treated with hydric sulphide. If, however, zinc is sought for as a part of a systematic examination (as will most likely be the case), the substance will have been treated with hydrochloric acid, and already tested for arsenic, antimony, lead, &c., and filtered from any precipitate. In such a case the hydrochloric acid must first be replaced by acetic, which is effected by adding a slight excess of sodic acetate; the right quantity of the latter is easily known, if the hydrochloric acid originally added was carefully measured, and its specific gravity ascertained; 3·72 of crystallised sodic acetate saturating one of HCl. Lastly, should the distillation process, given at p. 52, have been adopted, the contents of the retort will only require to be treated with water, filtered, and saturated with sulphuretted hydrogen. In any of the above cases, should a white, dirty-white or lightish coloured precipitate (which is not sulphur) be thrown down, zinc may be suspected; it will, however, be absolutely necessary to identify the sulphide, for there are many sources of error. The most satisfactory of all identifications is the production of Rinman's green. The supposed sulphide is dissolved off the filter with hot nitric acid, a drop or more (according to the quantity of the original precipitate) of solution of cobalt nitrate added, the solution precipitated with carbonate of soda and boiled, to expel all carbonic anhydride; the precipitate is then collected on a filter, washed, dried, and ignited in a platinum dish. If zinc be present in so small a proportion as 1·100,000 part, the mass will be permanently green.

Other methods of procedure are as follows:—The supposed zinc sulphide, (after being well washed) is collected in a porcelain dish, and dissolved in a few drops of sulphuric acid, filtered, nitric acid added, evaporated to dryness, and heated to destroy all organic matter. When cool, the mass is treated with water acidulated by sulphuric acid, and again filtered. The solution may contain iron as well as zinc, and if the former (on testing a drop with ferrocyanide of potash) appears in any quantity, it must be separated by the addition of ammonia in excess to the ammoniacal filtrate; sodic carbonate is added in excess, the liquid well boiled, and the precipitate collected on a filter and washed. The carbonate of zinc thus obtained is converted into zinc oxide by ignition, and weighed. If oxide of zinc, it will be yellow when hot, white when cold; it will dissolve in acetic acid; give a white precipitate with sulphuretted hydrogen; and, finally, if heated on charcoal in the oxidising flame, and moistened with cobalt nitrate solution, a green colour will result. Zinc may also be separated from liquids by electrolysis. The simplest way is to place the fluid under examination in a platinum dish of sufficient size, acidify, and insert a piece of magnesium tape. The metallic film so obtained may be dissolved by hydrochloric acid, and the usual tests applied.

2. NICKEL—COBALT.

The salts of nickel and cobalt have at present no toxicological importance, although, from the experiments of Anderson Stuart,* both may be classed as poisonous. The experiments of Gmelin had, prior to Stuart's researches, shown that nickel sulphate introduced into the stomach acted as an irritant poison, and, if introduced into the blood, caused death by cardiac paralysis. Anderson Stuart, desiring to avoid all local irritant action, dissolved nickel carbonate in acid citrate of soda by the aid of a gentle heat; he then evaporated the solution, and obtained a glass, which, if too alkaline, was neutralised by citric acid, until its reaction approximated to the feeble alkalinity of the blood; the cobalt salt was produced in the same way. The animals experimented on were frogs, fish, pigeons, rats, guinea-pigs, rabbits, cats and dogs—in all 200. The lethal dose of nickelous oxide, when subcutaneously injected in the soluble compound described, was found to be as follows:—frogs ·08 grm. per kilogram; pigeons ·06; guinea-pigs ·030; rats ·025; cats ·01; rabbits ·009; and dogs ·007. The cobaltous oxide was found to be much less active, requiring the above doses to be increased about two-thirds. In other respects, its physiological action seems to be very similar to that of nickelous oxide.

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* "Nickel and Cobalt; their Physiological Action on the Animal Organism." by T. P. Anderson Stuart, M.D.—*Journal of Anat. and Physiol.*, vol. xvii., Oct., 1882.

Symptoms—Frogs.—A large dose injected into the dorsal lymph sac of the frog, causes the following symptoms:—The colour of the skin all over the body becomes darker and more uniform, and not infrequently a white froth is abundantly poured over the integument. In an interval of about twenty minutes the frog sits quietly, the eyes retracted and shut; if molested, it moves clumsily. When quiet, the fore limbs are weak, and the hind legs drawn up very peculiarly, the thighs being jammed up so against the body, that they come to lie on the dorsal aspect of the sides of the frog, and the legs are so much flexed that the feet lie on the animal's back, quite internal to the plane of the thighs. Soon fibrillary twitchings are observed in the muscles of the abdominal wall, then feeble twitchings of the fingers, and muscles of the fore limbs generally; lastly, the toes are seen to twitch, and then the muscles of the hind limbs—this order is nearly always observed; now spasmodic gaping and incoördinate movements are seen, and the general aspect is not unlike the symptoms caused by picrotoxin. After this, tetanus sets in, and the symptoms then resemble those of strychnine; the next stage is stupefaction and voluntary motor paresis; the respiratory movements become feeble, and the paresis passes into paralysis. The heart beats more and more slowly and feebly, and death gradually and imperceptibly supervenes. The *post-mortem* appearances are well marked—*i.e.*, rigor mortis, slight congestion of the alimentary tract, the heart, with the auricle much dilated and filled with dark blood, the ventricle, mostly small, pale, and semi-contracted. For some time after death, the nerve trunks and muscles react to the induction current.

Pigeons.—In experiments on pigeons, the symptoms were those of dulness and stupor, jerkings of different sets of muscles, and then death quietly.

Guinea-pigs.—In guinea-pigs, there were dulness and stupefaction, with some weakness of the hind limbs.

Rats.—The symptoms in rats were almost entirely nervous; they became drowsy and apathetic, and there was paralysis of the hind legs.

Rabbits.—In rabbits, also, the symptoms were mainly those caused by an affection of the nervous system. There was paralysis, which affected either the hind legs only, or all four limbs. The cervical muscles became so weak that the animal was unable to hold its head up. Diarrhœa occurred and persisted until death. If the dose is not large enough to kill rapidly, the reflex irritability is decidedly increased, so that the slightest excitation may cause the animal to cower and tremble all over. Now appear twitchings and contractions of single groups of muscles, and this excitement becomes general. The respirations also become slower, and more difficult, and sometimes there is well-marked dilatation of the vessels of the ears and *fundi oculi*. Convulsions close the scene.

Circulation.—The effect of the salt on the frog's heart was also studied in detail. It seems that, under the influence of soluble salt of nickel, the heart beats more and more slowly, it becomes smaller and paler, and does not contract evenly throughout the whole extent of the ventricle; but the rhythm of the ventricular and auricular contractions is never lost.

It is probable that there is a vaso-motor paralysis of the abdominal vessels; the blood-pressure falls, and the heart is not stimulated by the blood itself as in its normal state. In support of this view, it is found that, by either pressing on the abdomen or simply inverting the frog, the heart swells up, fills with blood, and for a time beats well.

Nervous System.—The toxic action is referable to the central nervous system, and not to that of peripheral motor nerve-endings or motor nerve-fibres. It is probable that both nickel and cobalt paralyse to some extent the cerebrum. The action on the nerve-centres is similar to that of platinum or barium, and quite different from that of iron.

Action on Striped Muscle.—Neither nickel nor cobalt has any effect on striped muscle. In this they both differ from arsenic, antimony, mercury, lead, and iron—all of which, in large doses, diminish the work which healthy muscle is capable of performing.

Separation of Nickel or Cobalt from the Organic Matter Tissues.—It is very necessary, if any case of poisoning should occur by either or both of these metals, to destroy completely the organic matters by the processes already detailed on p. 52. Both nickel and cobalt are thrown down, if in the form of acetate, from a neutral solution by sulphuretted hydrogen; but the precipitation does not take place in the presence of free mineral acid; hence, in the routine process of analysis, sulphuretted hydrogen is passed into the acid liquid, and any precipitate filtered off. The liquid is now made almost neutral by potassic carbonate, and then potassic acetate added, and a current of sulphuretted hydrogen passed through it. The sulphides of cobalt and nickel, if both are present, will be thrown down; under the same circumstances zinc, if present, would also be precipitated. Cobalt is separated from zinc by dissolving the mixed sulphides in nitric acid, precipitating the carbonates of zinc and cobalt by potassic carbonate, collecting the carbonates, and, after washing, igniting them gently in a bulb tube, in a current of dry hydrochloric acid; volatile zinc chloride is formed and distils over, leaving cobalt chloride.

To estimate cobalt, sulphide of cobalt may be dissolved in nitric acid, and then precipitated by pure potash; the precipitate washed, dried, ignited, and weighed; 100 parts of cobaltous oxide (Co_3O_4) equals 73·44 of metallic cobalt. Cobalt is separated from nickel by a method essentially founded on one proposed by Liebig. The nitric acid solution of nickel and cobalt (which must be free from all other metals, save potassium or sodium) is nearly neutralised by potassic carbonate, and mixed with an excess of hydrocyanic acid, and then with pure caustic potash. The mixture is left exposed to the air in a shallow dish for some hours, a tripotassic cobalticyanide (K_3CoCy_6) and a nickelo-potassic cyanide ($2KCy,NiCy_4$) are in this way produced; if this solution is now boiled with a slight excess of mercuric nitrate, hydrated nickelous oxide is precipitated, but potassic cobalticyanide remains in solution, and may be filtered off. On carefully neutralising the alkaline filtrate with nitric acid, and adding a solution of mercurous nitrate, the cobalt may then be precipitated as a mercurous cobalticyanide, which may be collected, washed, dried, decomposed by ignition, and weighed as cobaltous oxide. After obtaining both nickel and cobalt oxides, or either of them, they may be easily identified by the blow-pipe. The oxide of nickel gives, in the oxidising flame with borax, a yellowish-red glass, becoming paler as it cools; the addition of a potassium salt colours the bead blue. In the reducing flame the metal is reduced, and can be seen as little greyish particles disseminated through the bead. Cobalt gives an intense blue colour to a bead of borax in the oxidising flame.

IV.—PRECIPITATED BY AMMONIUM SULPHIDE.

IRON—CHROMIUM—THALLIUM.

1. IRON.

It was Orfila's opinion that all the salts of iron were poisonous, if given in sufficient doses; but such salts as the carbonate, the phosphate, and a few others, possessing no local action, may be given in such very large doses, without causing disturbance to the health, that the statement must only be taken as applying to the more soluble iron compounds. The two preparations of iron which have any forensic importance are the perchloride and the sulphate.

Ferric Chloride ($Fe_2Cl_6 = 325$).—Anhydrous ferric chloride will only be met with in the laboratory. As a product of passing dry chlorine over red-hot iron, it sublimes in brown scales, is very deliquescent, and hisses when thrown into water. There are two very definite hydrates—one with 6 atoms of water, forming large, red deliquescent crystals; and another with 12 of water, less deliquescent, and crystallising in orange stellate groups.

The pharmaceutical preparations in common use are:—

Strong Solution of Perchloride of Iron (*Liquor Ferri Perchloridi Fortior.*—An orange-brown liquid of specific gravity 1·338, and containing about 52·88 parts per weight of ferric chloride in every 100 by volume.

Tincture of Perchloride of Iron (*Tinctura Ferri Perchloridi*), made by diluting 5 parts of the strong solution with 15 volumes of rectified spirit; it therefore contains about 1·31 per cent. parts by weight of ferric chloride in every 100 volume.

Solution of Perchloride of Iron (*Liquor Ferri Perchloridi.*)—Simply 5 volumes of the strong solution made up to 20 by the addition of water; hence, of the same strength as the tincture.

Effects of Ferric Chloride on Animals.—A very elaborate series of researches on rabbits, dogs, and cats, was undertaken a few years ago by MM. Bérenger-Férraud and Porte* to elucidate the general symptoms and effects produced by ferric chloride under varying conditions. First, a series of experiments showed that, when ferric chloride solution was enclosed in gelatine capsules and given with the food of the animal, it produced either no symptoms or but trifling inconvenience, even when the dose exceeded 1 grm. per kilogrm.; anhydrous ferric chloride and the ferric chloride solution were directly injected into the stomach, yet, when food was present, death did not occur, and the effects soon subsided. In animals which were fasting, quantities of the solution equal to ·5 grm. per kilogrm. and above caused death in from one hour to sixteen hours, the action being much accelerated by the addition of alcohol, as, for example, in the case of the tincture: the symptoms were mainly vomiting and diarrhœa, sometimes the vomiting was absent. In a few cases the posterior extremities were paralysed and the pupils dilated; the urine was scanty or quite suppressed; death was preceded by convulsions.

Effects on Man.—Perchloride of iron in the form of tincture has been popularly used in England, from its supposed abortive property, and is sold under the name of "steel drops." It has been frequently taken by mistake for other dark liquids; and there is at least one case on record in which it was proved to have been used for the purpose of murder. The latter case * is peculiarly interesting from its great rarity; it occurred in Martinique, in 1874–1876, no less than four persons being poisoned at different dates. All four were presumed to have had immoral relations with a certain widow X——, and to have been poisoned by her son. In three of the four cases, viz., Char——, Duf—— and Lab——, the cause of death seems pretty clear; but the fourth, Ab——, a case of strong suspicion, was not sufficiently investigated. All three took the fatal dose in the evening, between eight and nine o'clock—Lab—— the 27th of December, 1874; Duf—— the 22d of February, 1876; and Char—— on the 14th of May, 1876. They had all passed the day in tippling, and they all had eaten nothing from midday; so that the stomach would, in none of the three, contain any solid matters. The chloride was given to them in a glass of "punch," and there was strong evidence to show that the son of the widow X—— administered it. Char—— died after about thirteen hours' illness; Duf—— and Lab—— after sixty-five hours' illness; Ab—— lived from three to four days. With Clar—— the symptoms were very pronounced in an hour, and consisted essentially of violent colicky pain in the abdomen and diarrhœa, but there was no vomiting; Duf—— had also great pain in the abdomen and suppression of the urine. Lab—— had most violent abdominal pains; he was constipated, and the urinary secretion was arrested; there was besides painful tenesmus. According to the experiments of Bérenger-Férraud and Porte,† the perchloride in the above cases was taken under conditions peculiarly favourable for the development of its toxic action—viz., on an empty stomach and mixed with alcohol.

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* *Etude sur l'empoisonnement par le perchlorure de fer, par MM. Bérenger-Férraud et Porte.—Annals d'Hygiène Publique*, 1879.

There have been several cases of recovery from large doses of the tincture—*e.g.*, that of an old man, aged seventy-two, who had swallowed 85 cc. (3 oz.) of the tincture; the tongue swelled, there were croupy respiration, and feeble pulse, but he made a good recovery. In other cases ‡ 28·3 cc (an oz.) and more have caused vomiting and irritation of the urinary organs. The perchloride is not unfrequently used to arrest hæmorrhage as a topical application to the uterine cavity—a practice not free from danger, for it has before now induced violent inflammation and death from peritonitis.

Elimination of Iron Chloride.—Most of the iron is excreted in the form of sulphide by the fæces, and colours them of a black hue; a smaller portion is excreted by the urine.

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* Fully reported in Bérenger-Férraud's paper, *loc. cit.*

† *Dub. Med. Press*, Feb. 1849.

‡ *Provincial Journal*, April 7 and 21, 1847, p. 180; see also Taylor's "Principles and Practice of Medical Jurisprudence," vol. i., p. 320, 2d Edition.

Post-mortem Appearances.—In the experiments on animals already referred to, the general changes noted were dryness, pallor, and parchment-like appearance of the cavity of the mouth, the mucous membrane being blackened by the contact of the liquid. The gullet was pale and dry, not unfrequently covered with a blackish layer. The mucous membrane of the stomach was generally healthy throughout; but, if the dose was large and very concentrated, there might be one or more hyperæmic spots; otherwise, this did not occur. The internal surface of the intestines, similarly, shower no inflammation, but was covered with brownish coating which darkened on exposure to the air. The liver, in all the experiments, was large and gorged with black and fluid blood; there were ecchymoses in the lungs and venous congestion. The kidneys were usually hyperæmic, and contained little hæmorrhages. There was also general encephalic engorgement, and in one experiment intense congestion of the meninges was observed. Few opportunities have presented themselves for pathological observations relative to the effects produced by ferric chloride on man. In a case related by Christison, in which a man swallowed 42·4cc. (one and a half ounce) of the tincture, and died in five weeks, there was found thickening and inflammation of the pyloric end of the stomach.

The case of Char——, already alluded to, is that in which the most complete details of the autopsy are recorded, and they coincide very fairly with those observed in animals; the tongue was covered with a greenish fur, bordered at the edges with a black substance, described as being like "mud;" the lining membrane of the gullet was pale, but also covered with this dark "mud." The stomach contained a greenish-black liquid; the liver was large and congested; the kidneys were swollen, congested, and ecchymosed; the cerebral membranes were gorged with blood, and whole brain hyperæmic.

Ferrous Sulphate, Copperas, or Green Vitriol—$FeSO_4 7H_2O = 132 + 126$; specific gravity, anhydrous, 3·138, crystals 1·857; composition in 100 parts, FeO 25·92; SO_3 28·77; H_2O 45·32. This salt is in beautiful, transparent, bluish-green, rhomboidal prisms. The crystals have an astringent, styptic taste, are insoluble in alcohol, but dissolve in about 1·5 times their weight of water; the commercial article nearly always responds to the tests, both for ferrous and ferric salts, containing a little persalt. The medicinal dose of this salt is usually given, as from ·0648 to ·324 grm. (1 to 5 grains), but it has been prescribed in cases requiring it in gramme (15·4 grains) doses without injury. Sulphate of iron has many technical applications; is employed by all shoemakers, and is in common use as a disinfectant. The salt has been employed for criminal purposes in France, and in this country it is a popular abortive. In recorded cases the symptoms, as well as the pathological appearances, have a striking resemblance to those produced by the chloride. There are usually colic, vomiting and purging, but in one case (reported by Chevallier), in which a man gave a large dose of sulphate of iron to his wife, there was neither vomiting nor colic; the woman lost her appetite, but slowly recovered. Probably the action of ferrous sulphate, like that of the chloride, is profoundly modified by the presence or absence of food in the stomach. Anything like 28·3 grms. (an ounce) of sulphate of iron must be considered a dangerous dose, for, though recovery has taken place from this quantity, the symptoms have been of a violent kind.

Search for Iron Salts in the Contents of the Stomach, &c.—Iron, being a natural component of the body, care must be taken not to confound the iron of the blood or tissues with the "iron" of a soluble salt. Orfila attempted to distinguish between the two kinds of iron by treating the contents of the stomach, the intestines, and even the tissues, with cold acetic acid, and allowing them to digest in it for many hours, before filtering and testing for iron in the filtrate—and this is generally the process which has been adopted. The acid filtrate is first treated with sulphuretted hydrogen, which gives no precipitate with iron, and then with sulphide of ammonium, which precipitates iron black. The iron sulphide may be dissolved by a little hydrochloric acid and a drop of nitric acid, and farther identified by its forming Prussian blue when tested by ferrocyanide of potash, or by the bulky precipitate of oxide, when the acid liquid is alkalised by ammonia. In the case of Duf——, the experts attempted to prove the existence of foreign iron in the liver by taking 100 grms. of Duf——'s liver, and 100 grms. of the liver of a non-poisoned person, and destroying each by nitro-muriatic acid, and estimating in each acid solution the ferric oxide. Duf——'s liver yielded in 100 parts ·08 mgrm. of ferric oxid, the normal liver ·022—nearly three times as much as Duf——'s.

To obtain iron from the urine, the fluid must be evaporated down to a syrup in a platinum dish, a little nitric acid added, heated, and finally completely carbonised. The residue is dissolved in hydrochloric acid. Normal urine always contains an unweighable trace of iron; and, therefore, any quantity, such as a mgrm. of ferric oxide, obtained by careful precipitation of the hydrochloric acid solution out of 200 to 300 cc. of urine, would be good evidence that a soluble salt of iron had been taken. The hydrochloric acid solution is first precipitated by ammonia and ammonic sulphide. The precipitate thus obtained will not be pure iron sulphide, but mixed with the earth phosphates. It should be redissolved in HCl, precipitated by sodic carbonate, and then acidified by acetic acid and sodic acetate added, and the solution well boiled; the iron will then be precipitated for the most part as oxide mixed with a little phosphate of iron.

Since, as before mentioned, a great portion of the iron swallowed as a soluble salt is converted into insoluble compounds and excreted by the fæces, it is, in any case where poisoning by iron is suspected, of more importance to examine chemically the fæces, and the whole length of the alimentary canal, than even the contents of the stomach. In particular, any black material lying on the mucous membrane may be sulphide of iron mixed with mucus, &c., and should be detached, dissolved in a little hydrochloric acid, and the usual tests applied.

In the criminal cases alluded to, there were iron stains on certain linen garments which acquired an importance, for, on dissolving by the acid of nitric acid, they gave the reactions of chlorine and iron. Any stains found should be cut out, steeped in water, and boiled. If no iron is dissolved the stain should then be treated with dilute nitric acid, and the liquid tested with ferrocyanide of potash, &c. It need scarcely be observed that iron-mould is so common on shirts and any fabric capable of being washed, that great care must be exercised in drawing conclusions from insoluble deposits of the oxide.

2. CHROMIUM.

The only salts of chromium of toxicological importance are the neutral chromate of potash, the bichromate of potash, and the chromate of lead.

Neutral Chromate of Potash.—$CrO_3K_2O = 194{\cdot}7$, containing 56·7 per cent. of its weight of chromic anhydride, CrO_3. This salt is in the form of citron-yellow rhombic crystals, easily soluble in water, but insoluble in alcohol. Its aqueous solution is precipitated yellow by lead or baric acetate; the precipitate being insoluble in acetic acid. If chromate of potash in solution is tested with silver nitrate, the red chromate of silver is thrown down; the precipitate is with difficulty soluble in dilute nitric acid.

Potassic Bichromate.—$2CrO_3K_2O = 295{\cdot}2$, containing 68·07 per cent., of its weight of chromic anhydride, CrO_3. This salt is in beautiful large, red, transparent, four-sided tables; it is anhydrous and fuses below redness. At a high temperature, it is decomposed into green oxide of chromium and yellow chromate of potash. It is insoluble in alcohol, but readily soluble in water. The solution gives the same precipitates with silver, lead, and barium as the neutral chromate. On digesting a solution of the bichromate with sulphuric acid and alcohol, the solution becomes green from the formation of chromic oxide.

Neutral Lead Chromate.—$PbCrO_4 = 323{\cdot}5$, composition in 100 parts, PbO 68·94, CrO_3 31·06. This is technically known as "*Chrome Yellow,*" and is obtained as a yellow precipitate whenever a solution of plumbic acetate is added, either to the solutions of potassic chromate or bichromate; by adding chrome yellow to fused potassic nitrate, "chrome red" is formed; it has the composition $CrO^3 2PbO$. Neutral lead chromate is insoluble in acids, but may be dissolved by potassic or sodic hydrates.

Use in the Arts.—Potassic bichromate is extensively used in the arts—in dyeing, calico-printing, the manufacture of porcelain, and in photography; the neutral chromate has been employed to a small extent as a medicine, and is a common laboratory reagent; lead chromate is a valuable pigment.

Effects of some of the Chromium Compounds on Animal Life.—In the chromates of potash there is a combination of two poisonous metals, so that it is not surprising that Gmelin found the chloride of chromium, $CrCl_3$, less active than the neutral chromate of potash; 1·9 grm. of the last, administered to a rabbit by the stomach, caused death within two hours, while 3 grms. of chromous chloride had no action. Subcutaneous doses of ·2 to ·4 grm. of neutral chromate (according to the experiments of E. Gergens[*] and Carl Posner[†]) act with great intensity on rabbits. Immediately after the injection, the animals are restless, and show marked dyspnœa; death often takes place within a few hours.

Diarrhœa does not seem, as a rule, to follow when the salt is administered by subcutaneous injection to animals; but Gmelin's rabbits had considerable diarrhœa when 1·9 grm. was introduced into the stomach. The same quantity, injected beneath the skin of a dog, caused loss of appetite, and, after six days, there was a dry exanthem on the back, and the hair fell off in patches; there was, however, neither diarrhœa nor vomiting. Bichromate of potash causes (according to the researches of Pelikan)[‡] symptoms similar to those produced by arsenic or corrosive sublimate; it acts as a powerful irritant of the stomach and intestinal canal, and may even cause inflammation; on its absorption a series of symptoms are produced, of which the most prominent are albuminuria, bloody urine, and emaciation. From ·06 to ·36 grm. (1–5½ grains) is fatal to rabbits and dogs.

Effects of some of the Chromium Salts on Man—Bichromate Disease.—In manufacturing potassic bichromate, the workmen exposed to the dust have suffered from a very peculiar train of symptoms, known under the name of "bichromate disease." It was first described in England by Dr. B. W. Richardson.* It appears that if the workmen inspire the particles chiefly through the mouth, a bitter and disagreeable taste is experienced, with an increase of saliva. This increase of the buccal secretion gets rid of most of the poison, and in that case but little ill effect is experienced; but those who keep the mouth closed and inspire by the nose, suffer from an inflammation of the septum, which gradually gets thin and ultimately ulcerated; finally the whole of the septum is in this way destroyed. It is stated that when a workman has lost his nasal septum, he no longer suffers from nasal irritation, and has a remarkable immunity from catarrh. The bichromate also causes painful skin affections—eruptions akin to eczema or psoriasis; also very deep and intractable ulcerations. These cutaneous maladies start from an excoriation; so long as the skin is not broken, there seems to be little local effect, if any. The effects of the bichromate are also seen in horses employed at the factories; the salt getting into a wound or crack in the leg, produces ulceration; horses may even lose their hoofs.

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[*] *Arch. f. Experiment. Pathol. u. Pharmakol.*, Bd. 6, Hft. 1 and 2. § 148, 1875.

[†] Virchow's *Arch. f. Path. Anat.*, Bd. 79, Hft. 2, § 333, 1880.

[‡] *Beiträge zur Gerichtl. Medicin, Toxikol. u. Pharmakodynamik.* Würzburg, 1858.

Acute poisoning by the chromates is rare. Falck has, however, been able to find in medical literature seventeen cases, six of which were suicidal, ten accidental, and in one the bichromate was used as an abortive. In a case of poisoning by the chromate of potash (related by Maschka),† in which a woman, aged twenty-five, took for a suicidal purpose a piece of potassic chromate, which she described as the size of a hazel nut (it would probably be at least 6 grms. in weight)—the chief symptoms were vomiting, diarrhœa, pain in the stomach, and rapid collapse; death took place fourteen hours after swallowing the poison.

In poisoning by potassic bichromate, there may be much variety in the symptoms, the more usual being those common to all irritant poisons —*i.e.*, vomiting, diarrhœa, and collapse with cramps in the limbs and excessive thirst; and the rarer affecting more especially the nervous system—such as narcosis, paralysis of the lower limbs, and dilatation of the pupils; occasionally there is slight jaundice.

In a case recently recorded by Dr. Macniven,‡ a man took a lump of bichromate of potash, estimated to be over 2 drachms (7·7 grms.). The symptoms commenced in fifteen minutes, and consisted of lightness in the head, and a sensation of great heat in the body, which was followed by a cold sweat; in twenty minutes he vomited; he then suffered from great pain in the stomach, giddiness, specks before the eyes, a devouring thirst, and there was loss of power over the legs. These symptoms, again, were followed by severe rigours and great coldness of the extremities. On the patient's admission to hospital, two hours after taking the poison, it was noted that the pupils were dilated, the face pale and cold, and the pulse feeble. He complained of intense epigastric pain, and a feeling of depression: there was some stupor; the stomach was emptied by emetics and by the stomach-pump, and the patient treated with tepid emollient drinks, whilst subcutaneous doses of sulphuric ether were administered. He made a good recovery.

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* *Brit. and For. Med. Chirurg. Review*, *Oct.* 1863. See also a paper by the same writer, read before the Medical Society, reported in the *Lancet*, March 11, 1882.

† *Prager Vierteljahrsschr. f. d. Prakt. Heild.*, Bd. 131, § 37. 1877. Schmidt's *Jahrb.* 1878, Bd. 178, § 237. See also Schuchardt in Maschka's *Handbuch*, Bd. ii., p. 3.

‡ "On a case of poisoning with Bichromate of Potash," by Ed. O. Macniven, M.B.—*Lancet*, Sept. 22nd, 1883.

In a case recorded by Mr. Wilson,[*] a man, aged sixty-four, was found dead in his bed twelve hours after he had gone to rest. During the night he was heard to snore loudly; there were no signs of vomiting or purging, and bichromate of potash was found in the stomach.[†]

Chromate of lead has also caused death. In one case[‡] the breathing of chromate of lead dust seems to have been fatal; and there is also a double poisoning recorded by Dr. Linstow,[§] of two children, aged three and a-half and one and three-quarter years respectively, who ate some yellow ornaments,[‖] which were used to adorn a cake, and which contained chrome yellow (chromate of lead). The younger died in two and the elder in five days. The symptoms were redness of the face, dullness, and an inclination to sleep; neither complained of pain; the younger one had a little diarrhœa, but the elder neither sickness nor purging.

Post-mortem Appearances.—We possess some very exact researches[¶] upon the pathological changes induced by subcutaneous injections of solutions of potassic bichromate on animals, and especially on the changes which the kidneys undergo. If the animal is killed, or dies a few hours after the injection, there are apparently no striking appearances, but a closer microscopical examination shows considerable changes. The epithelium of the tubuli contorti exhibits a yellow cloudiness, and the outline of the cells is irregular and jagged. The glomeruli are moderately injected, and their capsules contain an albuminous exudation; the canaliculi are filled with round cells imbedded in a fluid which, on heating, coagulates, and is therefore albuminous or fibrinous; probably this is the first stage of the formation of fibrinous casts.

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[*] *Med. Gazette*, p. 33, 734.

[†] See also cases recorded by Dr. M'Lachlan, *Glasgow Med. Journ.*, July, 1881; Dr. M'Crorie, *Ibid*, May, 1881; Dr. R. A. Warwick, *Lancet*, Jan. 31st, 1880; and Dr. Dunbar Walker, *Ibid*, Sept. 27th, 1879—a summary of all of which may be found in Dr. Macniven's paper, *loc. cit.*

[‡] *Ueber tödtliche Vergiftung durch Einathmen des Staubes von mit Chromsäuren Blei-Oxyde gefärbten Garne.—Vierteljahrsschr. f. Ger. Med.*, 1877, Bd. xx., vii., Hft., i. p. 29.

[§] *Ibid.*, Bd. xx., s. 60. 1874.

[‖] The ornaments were imitations of bees; each contained ·27 grms. gum tragacanth, ·0042 grm. neutral lead chromate.

[¶] C. Posner. *Op. cit.*

In the case quoted of the woman who poisoned herself with potassic chromate, very striking changes were found in the stomach and intestines. The stomach contained above a litre of dark chocolate fluid of alkaline reaction; the mucous membrane, in the neighbourhood of the cardiac and pyloric extremities, was swollen and red in sharply defined patches; portions of the epithelial layer were detached, the rest of the mucous membrane was of a yellow-brown colour, and the whole intestine, from the duodenum to the sigmoid flexure, was filled with a partly bloody, partly treacly-looking fluid; the mucous membrane, throughout its entire extent, was swollen, with numerous extravasations, and in places there were losses of substance. Similar appearances to these have been found in other instances; the anomalous case recorded by Mr. Wilson (*ante*) is an exception. In this instance a pint of inky, turpid liquid, which yielded to analysis potassic bichromate, was found in the stomach; but there were no marked changes anywhere, save a slight redness of the cardiac end of the gullet. In Linstow's two cases of poisoning by lead chromate, there were found in both fatty degeneration of the liver cells, and red points or patches of redness in the stomach and intestines. In the elder boy the changes in the duodenum were very intense, the mucous membrane was swollen and easily detached, in the upper part strongly injected with blood; in one place there was a perforation, and in several places the membrane was extremely thin. In the younger boy the kidneys seem to have been normal, in the elder congested and containing pus. Although it was clear that the two children died from lead chromate, a chemical analysis gave no result.

Detection of the Chromates and Separation of the Salts of Chromium from the Contents of the Stomach, &c.—If in the methodical examination of an unknown acid liquid, which has been already filtered from any precipitate that may have been obtained by sulphuretted hydrogen, this unknown liquid is made alkaline (the alkali only being added in slight excess), and hydrated chromic oxide is thrown down and mixed, it may be, with other metals of the second class; the precipitate may then be fused with nitre and potassic carbonate, and will yield potassic chromate, soluble in water, and recognised by the red precipitate which it gives with silver nitrate, the yellow with lead acetate, and the green colour produced by boiling with dilute sulphuric acid and a little alcohol or sugar. If by treating a complex liquid with ammonium hydrosulphide, sulphides of zinc, manganese and iron are thrown down mixed with chromic oxide, the same principles apply. If a chromate is present in the contents of the stomach, and the organic fluid is treated with hydrochloric acid and potassic chlorate, chromic chloride is formed, and dissolving imparts a green colour to the liquid—this in itself will be strong evidence of the presence of a chromate, but it should be supplemented by throwing down the oxide, and transforming it in the way detailed into potassic chromate.

3. THALLIUM.

Thallium was discovered by Crookes in 1861. Its atomic weight is 204; specific gravity, 11·81 to 11·91; melting point, 290°. It is a heavy diamagnetic metal, very similar to lead in its physical properties. The nitrate and sulphate of thallium are both soluble in water, the carbonate less so, requiring about 25 parts of water for solution, while the chloride is sparingly soluble, especially in hydrochloric acid.

Effects.—All the salts of thallium are poisonous. One of the earlier experimenters on the physiological action, Paulet, found 1 grm. (15·4 grains) of thallium carbonate sufficient to kill a rabbit in a few hours; there were loss of muscular power, trembling of the limbs, and death apparently from asphyxia. Lamy* used thallium sulphate, and found that dogs were salivated, and suffered from trembling of the limbs, followed by paralysis. The most definite results were obtained by Marmé,† who found that ·04 to ·06 grm. of a soluble thallium salt, injected subcutaneously or directly into the veins, and ·5 grm. administered through the stomach of rabbits, caused death. The action is cumulative, and something like that of mercury: there are redness and swelling of the mucous membrane of the stomach, with mucous bloody discharges, and hæmorrhage may also occur from the lungs. Thallium is eliminated through the urine, and is also found in the fæces; it passes into the urine from three to five minutes after injection; the elimination is slow, often taking as long as three weeks. It has been found in the milk, in the tears, in the mucous membrane of the mouth, of the trachea, in the secretion of the gastric mucous membrane, and in the pericardial fluid; and in these places, whether the poison has been introduced by subcutaneous injection, or by any other channel. It seems probable that the reason of its being detected so readily in all the secretions, is the minute quantity which can be discovered by spectroscopic analysis.

Separation of Thallium from Organic Fluids or Tissues.—The salts of thallium, if absorbed, would only be extracted in traces from the tissues by hydrochloric acid, so that, in any special search, the tissues are best destroyed by either sulphuric or nitric acid, or both. In the ordinary method of analysis, when an acid liquid is first treated with sulphuretted hydrogen, and then made alkaline by ammonia and ammonic sulphide, thallium would be thrown down with the manganese and iron of the blood. From the mixed sulphides, thallium may be separated by oxidising and dissolving the sulphides with nitric acid, evaporating off the excess of acid, dissolving in a very little hot water, and precipitating thallous chloride by solution of common salt. The ease, however, with which thallium may be separated from solutions of its salts by galvanism is so great as to render all other processes unnecessary: the best way, therefore, is to obtain a deposit of the metal on platinum by a current from one or more cells, and then to examine the deposit spectroscopically. Thallium gives, when heated in a Bunsen flame, a magnificent green line, the centre of which corresponds with wave length 534·9; a second green line, the centre of which coincides with W.L. 568. may also be distinguished.

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* *Chem. News*, 1863.

† *Göttinger Gelehrt. Nachrichten*, Aug. 14, No. 20.

V.—ALKALINE EARTHS.

BARIUM.

The soluble salts of barium are undoubtedly poisonous, and are of frequent occurrence in the arts. The chloride of barium is used in the staining of wool, the nitrate and the chlorate in the green fires of the pyrotechnist, the oxide and the carbonate in the manufacture of glass. The chromate is used by artists under the name of "yellow ultramarine," while the sulphate, technically known as "permanent white," is, on account of its weight and cheapness, occasionally used as an adulterant of white powders and other substances.*

Chloride of Barium, $BaCl_2 2H_2O$ 208+36; anhydrous, Ba 65·86 per cent., Cl 34·14; specific gravity, 3·75—is in commerce in the form of white, four-sided, tabular crystals; water dissolves about half its weight at ordinary temperatures, three-fourths at 100°. Its solution gives a white precipitate with sulphuric acid, quite insoluble in water and nitric acid.

The salt imparts a green hue to an otherwise colourless flame; viewed by the spectroscope, green bands will be visible. We may note that chloride of barium gives two different spectra—the one at the moment of the introduction of the salt, the other when the substance has been exposed for some time to a high temperature. This is caused by a rapid loss of chlorine, so that the first spectrum is due to $BaCl_2$, with a variable mixture of BaCl, the second to BaCl alone.

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* Barium carbonate and sulphate are usually enumerated as occasional adulterants of bread, but there is no modern authentic instance of this.

Baric Carbonate, $BaCO_3 = 197$; specific gravity, 4·3; BaO 77·69 per cent., CO_2 22·31—in its native form termed *Witherite*, is a dense, heavy powder, insoluble in pure water, but dissolving in acetic, nitric, and hydrochloric acids, the solution giving the reactions of barium.

A rat-poison may be met with composed of baric carbonate, sugar, and oatmeal, flavoured with a little oil of aniseed and caraway.

Sulphate of Barium, $BaSO_4$; specific gravity, 4·59; BaO 65·06 per cent., SO_3 34·34 per cent., is a pure white powder when recently precipitated, absolutely insoluble in water, and practically insoluble in cold dilute acids. It is quite unalterable in the air at a red heat; on ignition with charcoal it may be converted almost entirely into sulphide of barium; and by ignition with $CaCl_2$ into chloride.

Effects of the Soluble Salts of Barium on Animals.—One of the early notices of the poisonous characters of barium compounds was by James Watt,[*] who found that *witherite*, given to dogs, produced vomiting, diarrhœa, and death in a few hours. Sir Benj. Brodie[‡] administered barium chloride, and noticed its paralysing effect on the heart. Orfila[‡] made several experiments, and observed that 4 grms. of the carbonate produced death in dogs in periods varying from one to five hours; but in these experiments the gullet was tied. The later investigators have been Gmelin, Onsum, Cyon, and Böhm.[§] Gmelin found barium carbonate and barium chloride act in a very similar manner; and, indeed, it is improbable that barium carbonate, *as* carbonate, has any action, but, when swallowed, the hydrochloric and other acids of the stomach form with it soluble compounds. J. Onsum made eight experiments with both barium carbonate and chloride on animals. The respiration was quickened and, at the same time, made weak and shallow; the heart's action was accelerated; the animals became restless; and there was great muscular prostration, with paralytic symptoms; convulsions did not occur in any one of the eight animals. He found, on *post-mortem* examination, the right side of the heart full of blood from backward engorgement; he describes a plugging of the small arteries with little fibrinous coagula, having an inorganic nucleus, with constant hæmorrhagic extravasations. Onsum seems to have held the theory that the baryta salts circulated in the blood, and then formed insoluble compounds, which were arrested in the lungs, causing minute emboli, just in the same way as if a finely-divided solid were introduced directly into the circulation by the jugular vein.

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[*] "Memoirs of the Literary and Philosophical Society of Manchester," 1790, vol. iii., p. 609.

[†] *Phil. Trans.*, 1812.

[‡] *Traité des Poisons*, 3d ed., T. 1., Paris, 1826.

[§] Gmelin, C. G., *Versuche über die Wirkungen des Baryts, Strontians, Chroms, Molybedäns, Wolframs, Tellurs, u. w. auf den thierischen Organismus*, Tübingen, 1824. Onsum, J., Virchow's *Archiv*, Bd. 2nd, 1863. Cyon, M., *Archiv f. Anatomie, Physiologie, &c.*, 1866. Böhm, *Archiv f. Experiment. Pathol.*, Bd. 3rd. 1874.

Onsum stands alone in this view. Cyon found no emboli in the lungs, and refers the toxic effect to a paralysing influence on the heart and voluntary muscles, and also on the spinal cord. Cyon, to settle the embolic theory, injected into the one jugular vein of a rabbit barium chloride, and into the other sodic sulphate, but the small arteries and capillaries of the lungs remained clear. Böhm, operating on frogs, found a great similarity between the action of small doses of barium salts and that of certain organic poisons; as, for example, cicutoxin, ·012 to ·02 grm., subcutaneously injected into frogs, acted as a heart-poison. So also Blake* found the heart slowed, and concluded that barium chloride had a direct action on the cardiac muscle, and also a toxic influence on the nervous system. F. A. Falck, in experiments on rabbits, found a great reduction of temperature after poisoning with barium chloride (3° to 12·6°).

Effects of the Salts of Barium on Man.—There are about fifteen cases of poisoning by barium salts on record—three of which were suicidal, but most of them were due to accident or mistake. In three cases, barium chloride was taken instead of Glauber's salts; in one, instead of Carlsbad salts; in another, a mixture of barium nitrate and sulphur, instead of pure sulphur; in a sixth case, a mixture of barium acetate and raspberry syrup, instead of sodic ethylsulphate; in a seventh, a chemist put a larger dose than was ordered by the prescription; and in four cases barium carbonate had been mixed with flour, and this flour used in the making of pastry. Of the fifteen cases, nine, or sixty per cent., proved fatal.

Fatal Dose.—The above fifteen cases of poisoning have not satisfactorily settled the question as to the least fatal dose of the barium salts. 6·5 grms. (about 100 grains) of the chloride have destroyed the life of an adult woman in fifteen hours; 14 grms. (½ oz.) of the nitrate of baryta have killed a man in six and a half hours; and the carbonate of baryta has destroyed a person in the relatively small dose of 3·8 grms. (60 grains). On the other hand, certain continental physicians have prescribed barium chloride in large medicinal doses; for example, Pirondi † and Lisfranc ‡ have gradually raised the dose of barium chloride from 4 decigrams up to 3 grms. (48 grains) daily, given, of course, in divided doses. Pirondi himself took in a day 7·7 grms. (119 grains) without bad effect.

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* *Journ. of Anat. and Physiol.*, 2nd series, 1874.

† *De la Tumeur Blanche de Genou*, ed. 2, Paris, 1836.

‡ *Gaz. Med. de Paris*, 1835, No. 14.

Symptoms.—The effects produced on man are partly those of intestinal irritation, and partly affections of the nervous system. There are nausea, vomiting, pain in the stomach, a sense of cardiac oppression, muscular weakness, noises in the ears, disturbances of vision, cramps, and even paralysis. In Dr. Tidy's case,[*] in which a man, suffering from rheumatism, but otherwise healthy, took a mixture of barium nitrate, flowers of sulphur, and potassic chlorate, instead of sulphur—the symptoms were blisters on the tongue, a burning pain in the gullet and stomach, with vomiting, diarrhœa, convulsions, aphonia, and coldness of the extremities. A case, copiously detailed by Seidel,[†] in which a pregnant woman, twenty-eight years old, took carbonate of baryta for the purposes of self-destruction, is interesting. She probably took the poison some little time before six in the evening; she vomited and had great pain in the stomach, but slept during the night without further sickness. The next morning, after drinking some coffee, the sickness was renewed; nevertheless, at 7 a.m., she repaired to her employment, which was distant an hour's walk; she probably suffered much on the way, for she did not arrive until 9 a.m. The vomiting, accompanied by diarrhœa, continuing, she was sent to bed at 2 p.m. She was very cold, and complained of great weakness; the vomiting now ceased. At 8 p.m., she shivered violently, could scarcely swallow, and the respiration was oppressed. At 11 she seemed a little improved; but at 3 a.m. she was found much worse, breathing rapidly, but fully conscious. At 4 a.m. she was again seen, but found dead; she thus lived about thirty-four hours after taking the fatal dose.

Post-mortem Appearances.—The *post-mortem* appearances are usually changes in the stomach and intestinal tract, but there are only rarely traces of great inflammation. It is true, that in a case recorded by Wach,[‡] a perforation of the stomach was found; but, since there was old standing disease of both liver and stomach, it is not clear that this is to be attributed entirely to poison. In the case of suicide just detailed, the mucous membrane of the stomach was much ecchymosed; over the whole were strewn little white grains, sticking to the mucous membrane, and there were also ecchymoses in the duodenum.

The Separation of Barium Salts from Organic Solids or Fluids, and their Identification.—In the usual course of examination of an unknown substance, the matter will already have been extracted by hydrochloric acid, and the solution successively treated with hydric and ammonic sulphides. The filtrate from any precipitate, after being boiled, would in such a case give a precipitate if treated with sulphuric acid, should a salt of barium soluble in hydrochloric acid be present.

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[*] *Pharm. Journ.*, June, 1868.

[†] Eulenberg's *Vierteljahrsschrift f. Ger. Med.*, Bd . 27. § 213.

[‡] Henke's *Zeitschrift f. Staatsarzneik.*, 1835, Bd. 30, Hft. 1, § 1.

If there, however, should be *special* grounds to search for baryta in particular, it is best to extract the substances with pure boiling water, to concentrate the solution, and then add sulphuric acid, collecting any precipitate which may form. If the latter is found to be sulphate of baryta, it must be derived from some soluble salt, such as the nitrate or the chloride. The substances which have been exhausted with water are now treated with hydrochloric acid, and to the acid filtrate sulphuric acid is added. If sulphate of baryta is thrown down, the baryta present must have been a salt insoluble in water, soluble in acids—probably the carbonate. Lastly, the organic substances may be burnt to an ash, the ash fused with carbonate of soda, the mass, when cool, dissolved in HCl, and the solution precipitated with sulphuric acid. Any baryta now obtained was present, probably in the form of sulphate; nevertheless, if obtained from the tissues, it would prove that a soluble salt had been administered, for (so far as is known) sulphate of barium is not taken up by the animal fluids, and is innocuous.

The sulphate of barium is identified as follows:—

(1.) A part of the well-washed precipitate is boiled with distilled water, filtered, and to the filtrate a solution of chloride of barium added. If there is no precipitate, the sulphate can be none other than baric sulphate, for all the rest, without exception, are soluble enough to give a slight cloud with baric chloride.

(2.) The sulphate may be changed into sulphide by ignition on charcoal, the sulphide treated with HCl, the solution evaporated to dryness, and the resulting chloride examined spectroscopically; or, the sulphide may be mixed with chloride of calcium, taken up on a loop of platinum wire, heated strongly in the flame of a Bunsen burner, and the flame examined by the spectroscope.

(3.) A solution of the chloride of barium obtained from (2) gives a yellow precipitate with neutral chromate of potash, insoluble in water, but soluble in nitric acid.

APPENDIX A.

EXAMINATION OF BLOOD, OR OF BLOOD-STAINS.

Spots, supposed to be blood—whether on linen, walls, or weapons, should, in any important case, be photographed before any chemical or microscopical examination is undertaken. Blood-spots, according to the nature of the material to which they are adherent, have certain naked eye peculiarities—*e.g.*, blood on fabrics, if dry, has at first a clear carmine red colour, and part of it soaks into the tissue. If, however, the tissue has been worn some time, or was originally soiled, either from perspiration, grease, or filth, the colour may not be obvious or very distinguishable from other stains; nevertheless, the stains always impart a certain stiffness, as from starch, to the tissue. If the blood has fallen on such substances as wood or metal, the spot is black, has a bright glistening surface, and, if observed by a lens, exhibits radiating fissures and a sort of pattern, which, according to some, is peculiar to each species; so that a skilled observer might identify occasionally, from the pattern alone, the animal whence the blood was derived. The blood is dry and brittle, and can often be detached, or a splinter of it, as it were, obtained. The edges of the splinter, if submitted to transmitted light, are observed to be red. Blood upon iron is frequently very intimately adherent; this is specially the case if the stain is upon rusty iron, for hæmatin forms a compound with iron oxide. Blood may also have to be recovered from water in which soiled articles have been washed, or from walls, or from the soil, &c. In such cases the spot is scraped off from walls, plaster, or masonry, with as little of the foreign matters as may be. It is also possible to obtain in the colouring matter of blood from its solution in water, and present it for farther examination in a concentrated form, by the use of certain precipitating agents (see p. 618).

In the following scheme for the examination of blood-stains, it is presumed that only a few spots of blood, or, in any case, a small quantity, is at the analyst's disposal.

(1.) The dried spot is submitted to the action of a cold saturated solution of borax. This medium (recommended by Dragendorff)* does certainly dissolve out of linen and cloth blood-colouring matter with great facility. The best way to steep the spots in the solution is to scrape the spot off the fabric, and to digest it in about a cubic centimetre of the borax solution, which must not exceed 40° ; the coloured solution may be placed in a little glass cell, with parallel walls, ·5 centimetre broad, and ·1 deep, and submitted to spectroscopic examination, either by the ordinary spectroscope or by the micro-spectroscope ; if the latter is used, a very minute quantity can be examined, even a single drop. In order to interpret the results of this examination properly, it will be necessary to be intimately acquainted with the spectroscopic appearances of both ancient and fresh blood.

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* *Untersuchungen von Blutspuren* in Maschka's *Handbuch*. Bd. i., Halfband 2.

Spectroscopic Appearances of Blood.—If defibrinated blood * be diluted with water until it contains about ·01 per cent. of oxyhæmoglobin, and be examined by a spectroscope, the layer of liquid being 1 centimetre thick, a single absorption band between the wave lengths 583 and 575 is observed, and, under favourable circumstances, there is also to be seen a very weak band from 550 to 532. With solutions so dilute as this, there is no absorption at either the violet or the red end of the spectrum. A solution containing ·09 per cent. of oxyhæmoglobin shows very little absorption in the red end, but the violet end is dark up to about the wave length, 428. Two absorption bands may now be distinctly seen. A solution containing ·37 per cent. of oxyhæmoglobin shows absorption of the red end to about W.L. 820 ; the violet is entirely, the blue partly, absorbed to about 453. The bands are considerably broader, but the centre of the bands occupies the same relative position. A solution containing as much as ·8 per cent. of oxyhæmoglobin is very dark ; the two bands have amalgamated, the red end of the spectrum is absorbed nearly up to Fraunhofer's line *a ;* the green is just visible between W.L. 498 and 518. Venous blood, or arterial blood, which has been treated with reducing agents, such, for example, as an alkaline sulphide, gives the spectrum of reduced hæmoglobin. If the solution is equivalent to about ·2 per cent., a single broad band, with the edges very little defined, is seen to occupy the space between W.L. 595 and 538, the band being darkest about 550 ; both ends of the spectrum are more absorbed than by a solution of oxyhæmoglobin of the same strength. In the blood of persons or animals poisoned with hydric sulphide—to the spectrum of reduced hæmoglobin, there is added a weak absorption band in the red, with its centre nearly corresponding with the Fraunhofer line C. Blood which has been exposed to carbon oxide has a distinct spectrum, due, it would seem, to a special combination of this gas with hæmoglobin ; in other words, instead of oxygen, the oxygen of oxyhæmoglobin has been displaced by carbon oxide, and crystals of carbon oxide-hæmoglobin, isomorphous with those of oxyhæmoglobin, may be obtained by suitable treatment. The spectrum of carbon oxide-hæmoglobin, however, differs so little from that of normal blood, that it is only comparison with the ordinary spectrum, or careful measurements, which will enable any person, not very familiar with the different spectra of blood, to detect it; with careful and painstaking observation the two spectra are seen to be distinct. The difference between the carbon oxide and the normal spectrum essentially consists in a slight moving of the bands nearer to E. According to the measurements of Gamgee, the band *α* of CO-hæmoglobin has its centre approximately at W.L. 572, and the band *β* has for its centre W.L. from 534 to 538, according to concentration. If a small quantity of an ammoniacal solution of ferrous tartrate or citrate be added to blood containing carbon oxide, the bands do not wholly fade, but persist more or less distinctly; whereas, if the same solution is added to bright red normal blood, the two bands vanish instantly and coalesce to form the spectrum of reduced hæmoglobin. When either a solution of hæmoglobin or blood is exposed to the air for some time, it loses its bright red colour, becomes brownish-red, and presents an acid reaction. On examining the spectrum, the two bands have become faint, or quite extinct; but there is a new band, the centre of which (according to Gamgee) occupies W.L. 632, but (according to Preyer) 634. In solutions of a certain strength, four bands may be seen, but in a strong solution only one. This change in the spectrum is due to the passing of the hæmoglobin into *methæmoglobin,* which may be considered as an intermediate stage of decomposition, prior to the breaking up of the hæmoglobin into hæmatin and proteids.

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* In this brief notice of the spectroscopic appearances of the blood, the measurements in wave lengths are, for the most part, after Gamgee.—"Text-Book of Physiological Chemistry." London, 1880.

A spectrum very similar to that of methæmoglobin is obtained by treating ancient blood stains with acetic acid—viz., the spectrum of *acid hæmatin,* but the band is nearer to its centre, according to Gamgee, corresponding to W.L., 640, (according to Preyer, 656·6). The portion of the band is a little different in alkaline solution, the centre being about 592. Hæmatin is one of the bodies into which hæmoglobin splits up by the addition of such agents as strong acetic acid, or by the decomposing influence of exposure; the view most generally accepted being that the colouring-matter of the blood is hæmatin in combination with one or more albuminoid bodies. The hæmatin obtained by treating blood with acetic acid may be dissolved out by ether, and the ethereal solution then exhibits a remarkable distinctive spectrum. Hence, in the spectroscopic examination of blood, or solutions of blood, for medico-legal purposes, if the blood is fresh, the spectrum likely to be seen is either that of oxyhæmoglobin or hæmoglobin; but, if the blood stain is not recent, then the spectrum of either hæmatin or methæmoglobin.

The colouring-matter of cochineal, to which alum, potassic carbonate, and tartrate have been added, gives a spectrum very similar to that of blood (see page 83, vol. i.); but this is only the case when the solution is fresh. The colour is at once discharged by chlorine, while the colour of blood, although changed in hue, remains. The colouring-matter of certain red feathers, purpurin-sulphuric acid, and a few other reds, have some similarity to either the hæmatin or the hæmoglobin spectrum, but the bands do not strictly coincide; besides, no one would trust to a single test, and none of the colouring-matters other than blood yield hæmatin.

(2.) *Preparation of Hæmatin Crystals*—(Teichmann's crystals). A portion of the borax solution is diluted with five or six parts of water, and one or more drops of a five or six per cent. solution of zinc acetate added, so long as a brownish-coloured precipitate is thrown down. The precipitate is filtered off by means of a miniature filter, and then removed on to a watch glass. The precipitate may now be dissolved in one to two cc. of acetic acid, and examined by the spectroscope it will show the spectrum of hæmatin. A minute crystal of sodic chloride being then added to the acetic acid solution, it is allowed to evaporate to dryness at the ordinary temperature, and crystals of hæmatin hydrochlorate result. There are other methods of obtaining the crystals. When a drop of fresh blood is simply boiled with glacial acetic acid, on evaporation, prismatic crystals are obtained.

Hæmatin is insoluble in water, alcohol, chloroform, and in cold dilute acetic and hydrochloric acids. It may, however, be dissolved in an alcoholic solution of potassic carbonate, in solutions of the caustic alkalies, and in boiling acetic and hydrochloric acids. Hoppe-Seyler ascribes to the crystals the formula $C_{68}H_{70}N_8Fe_2O_{10}2HCl$. Thudichum considers that the pure crystals contain no chlorine, and are therefore those of hæmatin. It is the resistance of the hæmatin to decomposition and to ordinary solvents that renders it possible to identify a certain stain to be that of blood, after long periods of time. Dr. Tidy seems to have been able to obtain blood reactions from a stain which was supposed to be 100 years old. The crystals are of a dark-red colour, and present themselves in three forms, of which that of the rhombic prism is the most common (see fig. 20). But crystals like *b*, having six sides, also occur, and also crystals similar to *c*.

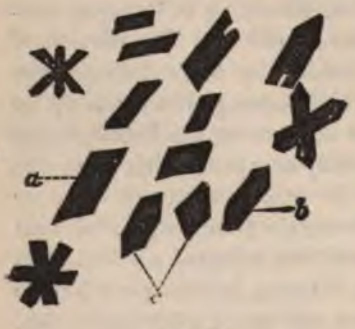

Fig. 20.

If the spot under examination has been scraped off an iron implement the hæmatin is not so easily extracted, but Dragendorff states that borax solution at 50° dissolves it, and separates it from the iron. Felletar has also extracted blood in combination with iron rust, by means of warm solution of caustic potash, and, after neutralisation with acetic acid, has precipitated the hæmin by means of tannin, and obtained from the tannin precipitate, by means of acetic acid, Teichmann's crystal.

Blood on leather must be treated in the same way as if it were a tannin precipitate—that is, the blood must be scraped off and boiled up with strong acetic acid, &c.

(3.) *Guaiacum Tests.*—This test depends upon the fact that a solution of hæmoglobin develops a beautiful blue colour, if brought into contact with fresh tincture of guaiacum and peroxide of hydrogen. The simplest way to obtain this reaction is to moisten the suspected stain with distilled water; after allowing sufficient time for the water to dissolve out some of the blood constituents, moisten a bit of filter-paper with the weak solution thus obtained; drop on to the moist space a single drop of tincture of guaiacum which has been prepared by digesting the inner portions of guaiacum resin in alcohol, and which has been already tested on known blood, so as to ascertain that it is really good and efficient for the purpose; and, lastly, a few drops of peroxide of hydrogen. Dragendorff uses his borax solution, and, after a little dilution with water, adds the tincture and then Heunefeld's turpentine solution, which is composed of equal parts of absolute alcohol, chloroform, and French turpentine, to which one part of acetic acid has been added. The chloroform separates, and, if blood was present, is of a blue colour.

To prove by chemical and physical methods that a certain stain is that of blood, is often only one step in the enquiry, the next question being whether the blood is that of man or of animals. The blood-corpuscles of man are larger than those of any domestic animal inhabiting Europe. The diameter of the average red blood-corpuscle is about the $\frac{1}{126}$ of a millimetre, or 7·9 μ.* The corpuscles of man and of mammals, generally speaking, are round, those of birds and reptiles oval, so that there can be no confusion between man and birds, fishes or reptiles; if the corpuscles are circular in shape the blood will be that of a mammal. By careful measurements, Dr. Richardson, of Pennsylvania, affirms that it is quite possible to distinguish human blood from that of all common animals. He maintains, and it is true, that, by using very high magnifying powers and taking much trouble, an expert can satisfactorily identify human blood, if he has some half-dozen drops of blood from different animals—such as the sheep, goat, horse, dog, cat, &c., all fresh at hand for comparison, and *if the human blood is normal.* However, when we come to the blood of persons suffering from disease, there are changes in the diameter, and even the form of the corpuscles, which much complicate the matter; while, in blood stains of any age, the blood-corpuscles, even with the most artfully-contrived solvent, are so distorted in shape that he would be a bold man who should venture on any definite conclusion as to whether the blood was certainly human, more especially if he had to give evidence in a criminal case.

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* $\frac{1}{3200}$ of an inch; the Greek letter μ is the micro-millimetre, or 1000th of a millimetre ·00003937 inch.

Neumann affirms that the pattern which the fibrin or coagulum of the blood forms, is peculiar to each animal, and Dr. Day, of Geelong, has independently confirmed his researches: this very interesting observation, perhaps, has not received the attention it merits.

When there is sufficient of the blood present to obtain a few milligrms. of ash, there is a means of distinguishing human blood from that of other common mammals, which has been neglected by authorities on the subject, and which may be found of real value. Its principle depends upon the relative amounts of potassium and sodium in the blood of man as compared with that in the blood of domestic animals. In the blood of the cow, sheep, fowl, pig, and horse, the sodium very much exceeds the potassium in the ash; thus the proportion of sodium oxide to that of potassium oxide in the blood of the sheep is as $K_2O \cdot 1 : Na_2O \cdot 6$; in that of the cow, as 1 : 8; in that of the domestic fowl, as 1 : 16; while the same substances in human blood are sometimes equal, and vary from 1 : 1 to 1 : 4 as extremes, the mean numbers being as 1 : 22. The potassium is greater in quantity in the blood corpuscles than in the blood serum; but, even in blood serum, the same marked difference between the blood of man and that of many animals is apparent. Thus, the proportion of potash to soda being as 1 : 10 in human blood; the proportion in sheep's blood is 1 to 15·7; in horse's serum as 1 to 16·4; and in the ox as 1 to 17. Since blood, when burnt, leaves from 6 to 7 per thousand of ash, it follows that a quantitative analysis of the relative amounts of potassium and sodium can only be satisfactorily effected when sufficient of the blood is at the analyst's disposal to give a weighable quantity of mineral matter. I, however, find that it is possible to make an estimation of the alkalies with 1 gramme of blood—this quantity yielding about 5 milligrammes of the mixed alkalies. On the other hand, much work requires to be done before this method of determining that the blood is either human, or, at all events, not that of an herbivorous animal, can be relied on. We know but little as to the effect of the ingestion of sodium or potassium salts on either man or animals, and it is possible—nay, probable—that a more or less entire substitution of the one for the other may, on certain diets, take place. Bunge seems in some experiments to have found no sodium in the blood of either the cat or the dog.

The source from which the blood has emanated, may, in a few cases, be conjectured from the discovery, by microscopical examination, of hair or of buccal, nasal, or vaginal epithelium, &c., mixed with the blood stain.

APPENDIX B.*

TREATMENT, BY ANTIDOTES OR OTHERWISE, OF CASES OF POISONING.

All medical men in practice are liable to be summoned hastily to cases of poisoning. In such emergencies not a moment is to be lost, for valuable lives have ere this been sacrificed simply from the delay caused by searching for medicines and instruments, and visiting the patient unprovided with suitable remedies. Hence, it is far the safest plan for every medical man to provide himself with an "*antidote bag*," which, to be complete, should be furnished with the following requisites :—

I. INSTRUMENTS :—

(1.) A **stomach-pump** or **tube**,† with proper mouth gags.
(2.) A **hypodermic syringe**.
(3.) An ordinary bleeding **lancet**.

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* The brief Summary given in Appendix B of the immediate steps which should be taken in cases of poisoning is added by request.

† The stomach-tube is simply a tube of India-rubber, from 6 to 8 feet in length, one end of which should be a little stiff, and have a solid rounded extremity pierced with two lateral oval holes—catheter-like; but, on an emergency, any India rubber tube of a suitable length will do. It is used by passing the proper end gently down the throat into the stomach; if the patient is insensible, or, as in some determined suicides, obstinate, the jaws must be forcibly opened by the handle of a spoon, and some solid substance placed between the teeth so as to give sufficient room for the entry of the tube. If the tube is now passed in the median line well into the grasp of the pharynx, it is actually drawn down into the stomach by the pharyngeal muscles, so that the operator has, as it were, only to "pay out" a sufficient quantity of the tubing. Holding the tube in a perpendicular position, it may then be filled with water by means of a small funnel. When full, the end must be pinched and brought down to the ground to deliver in a basin; it will then act as a syphon and the contents of the stomach will be syphoned off. The tube is elevated again above the body, and the stomach filled with water; this syphoned off, and the process repeated. Coffee, also, or antidotes may be conveniently introduced. If the recumbent position is necessary, the patient must, of course, be placed on a bed or table, in order that there should be sufficient fall for the syphon.

(4.) A **glass-syringe** with suitable canula, which may, in case of necessity, be used for transfusion.

(5.) **Bistoury, forceps** and **tubes** suitable for performing **tracheotomy.**.

A small **battery** (interrupted current).

II. EMETICS:—

(1.) *Sulphate of zinc.*
(2.) *Apomorphine.*
(3.) *Mustard.*
(4.) *Ipecacuanha.*

The *sulphate of zinc* may either be carried in thirty-grain powders or in the ordinary solid crystalline state, together with a little measure made out of a small pill-box which, when exactly full, is found to contain from twenty-five to thirty grains.

A still more convenient form is that of the compressed tablets, sold as a specialty by one or more firms. The same remarks apply to *ipecacuanha.*

The *apomorphine hydrochlorate* should be in solution, a suitable strength is 2 per cent.; a few drops of this substance, injected hypodermically, will cause vomiting in a few minutes.

Besides the above list, the bag should be furnished with a selection of the so-called antidotes.

ANTIDOTES:—

(*a.*) *Chemicals neutralising the poison.*

Acetic acid and **calcined magnesia.**

(*b.*) *Precipitants of alkaloids.*

Tannin—A solution of **iodine in potassic iodide.**

(*c.*) *Narcotics, or anæsthetics,* for the treatment of the tetanic class.

Chloral—chloroform.

(*d.*) *Substances which act physiologically.*

French oil of turpentine.—A solution of **atropine sulphate** for hypodermic use (strength ·8 per cent.); hypodermic dose from 5 to 6 drops.

Solution of **nitrate of pilocarpine** (strength 5 per cent.); dose, 10 drops or more.

Muscarine—a solution in water (strength 5 per cent.); dose, 10 drops.

Morphine meconate in solution (strength 10 per cent.); dose, from 5 drops.

A solution of **pilocarpine nitrate** (strength 5 per cent.); dose, about 10 drops.

A solution of **nitrate of strychnine** (strength 2 per cent.); hypodermic dose, from 2 to 3 drops.

To these may be added a bottle of **Wyeth's dyalised iron** for use in arsenic poisoning, a flask of **brandy,** some **chloric ether, aromatic spirits of ammonia.** and some really good **extract of coffee.**

TREATMENT.

ACID CARBOLIC.

Use the **stomach-tube** or **pump,** unless there is great destruction of the mucous membrane. In the latter case, excite vomiting by injecting subcutaneously from 5 to 6 drops of the **apomorphine** solution; or give an emetic of **zinc sulphate, ipecacuanha,** or **mustard.**

The stomach may, by the aid of the tube, be washed out with a weak alkaline solution of **soda: albumen** may also be given, and such stimulants as **brandy** and water, **chloric ether,** and **aromatic spirits of ammonia.**

It is important to apply warmth to the extremities.

Inject subcutaneously from 2 to 3 drops of the **atropine** hypodermic solution.

Nitrite of amyl by inhalation is said to have been useful.

In desperate cases **bleeding.** followed by **transfusion,** is to be considered.

ACIDS—MINERAL, including SULPHURIC, NITRIC, HYDROCHLORIC, GLACIAL ACETIC ACIDS.

Stomach-tube or **pump,** inadmissible.

Neutralise by calcined **magnesia, lime, chalk,** or **soda,** but not with potash, if there is choice.

If no neutralising agent can be immediately procured, then dilute with plenty of water.

Other remedies are—**oil, milk, whites of eggs, gruel.**

It is often recommended in such cases to administer hypodermically a little morphine.

ACONITE—ACONITINE.

Use at once the **stomach-tube** or **pump,** or give emetics of **sulphate of zinc,** or hypodermic solution of **apomorphine.**

Keep the patient in the recumbent posture.

After the stomach has been emptied, give **atropine,** either by hypodermic injection or by the mouth, say 4 drops of the P.B. solution; failing atropine, 20 drops of the tincture of **belladonna.** The dose may be repeated more or less frequently according to the condition of the patient.

If there is great tendency to heart-syncope, tincture of **digitalis** in ½-drachm doses by the mouth, or in hypodermic doses of from 10 drops upwards.

Apply a mustard poultice to the pericardium; aid vomiting and elimination of the poison by plenty of water, to which may be added brandy or any form of alcohol.

Inhalations of **nitrite of amyl** are said to have been useful. If the breathing stops, try **artificial respiration.**

ALCOHOL.

Empty the stomach by the **tube** or **pump,** and then wash it out with warm coffee; if the stomach-tube is not at hand, then empty the stomach by hypodermic injection of 5 drops of **apomorphine,** or by a **mustard** emetic, or **sulphate of zinc.** Keep the body very warm, but the cold **douche** may be applied to the head.

Endeavours should be made to rouse the patient, if insensible, by shaking, shouting at him, &c.

Inhalations of **amyl nitrite** are said to be useful.

ALKALIES—AMMONIA—POTASH—SODA.—**Stomach-pump** or **tube** not to be used.

Vomiting nearly always present, or may be produced by administering plenty of lukewarm water; after which give **dilute vinegar,** or the **juices** of **lemons or oranges; olive oil,** the **white of eggs, barley water, arrowroot,** and always plenty of **water** may be administered.

There may be œdema of the glottis, especially if ammonia has been taken. In such a case, and death threatening from suffocation, perform **tracheotomy.** In poisoning by ammonia, with croupous respiration, keep the room warm, and fill it with steam by means of a bronchitis kettle.

Relieve pain by small doses of **morphine** injected subcutaneously.

AMMONIA.—See ALKALIES.

ANTIARIN.—See DIGITALIS.

ANTIMONY—TARTAR-EMETIC—ANTIMONIAL WINE, &c.

The stomach will generally have been emptied by vomiting. In those rare cases in which this does not take place, use the **stomach-pump** or **tube,** or give hypodermic injection of **apomorphine.**

Follow this with doses of **strong tea**, or give half-a-drachm of **tannin** or **gallic acid** in warm water.

Give also demulcent drinks, and stimulants in small doses, frequently repeated.

Keep the patient very warm by hot blankets and wraps.

The interrupted galvanic current to the heart may be useful.

APOCYNIN.—See DIGITALIS.

ARSENIC.

Use the **stomach-pump** or **tube**, or empty stomach by emetics, such as hypodermic solution of **apomorphine**, or give **mustard** or **sulphate of zinc**. The stomach should then be washed out by large quantities of water, most conveniently administered by the pump or tube.

If the tube or pump is not at hand, then administer at once either **dialysed iron**, or the freshly-precipitated **hydrated oxide of iron**, obtained by precipitating the ordinary perchloride by means of carbonate of soda or ammonia, avoiding excess of the latter. If the operator has sufficient chemical knowledge to precipitate the iron with fair exactness, so that there is no great excess of ammonia, or of sodic carbonate, then filtration is unnecessary. In other cases, filter through a handkerchief.

Oil, mucilaginous drinks, the **whites of eggs**, and, if faintness exists, small doses of **stimulants** may all be given.

If the skin is cold, warmth must be applied to the body by means of hot blankets, &c.

Pain may be relieved by **morphine**.

ATROPINE—BELLADONNA—TINCTURE OF BELLADONNA.

Empty the stomach by means of the **stomach-pump** or **tube**.

Give an enema of **coffee**.

Administer half a grain of **pilocarpine nitrate**; or, if that is not at hand, **morphine** or **opium** in suitable doses will act to a certain extent antagonistic to the poison.

A subcutaneous dose of **muscarine** may be administered instead of pilocarpine, but is not quite so good.

Hot water to the feet, alternate **douches** of cold and hot water are sound useful.

If the respiration seems likely to stop, **artificial respiration** must be practiced

BELLADONNA.—See ATROPINE.

BENZENE.

If swallowed, then empty the stomach by **pump** or **tube**, or by the hypodermic injection of **apomorphine**; or give emetics, such as **zinc sulphate, mustard,** or **ipecacuanha.**

If the vapour has been *inhaled,* this is unnecessary.

Plenty of **fresh air.**

A subcutaneous dose of **atropine,** say 1-60th of a grain, or from 30 to 40 drops of **belladonna** tincture.

Alternate **douches** of hot and cold water to the chest, **artificial respiration.** if necessary. The heart to be maintained by mild interrupted shocks of the **battery** over the region of the heart.

BICHROMATE OF POTASH.—See CHROMIUM.

BRUCINE.—See STRYCHNINE.

CALABAR BEAN—PHYSOSTIGMINE.

Use **stomach-pump** or **tube,** or emetics, such as **sulphate of zinc, mustard,** or **ipecacuanha**: or, better still, hypodermic solution of **apomorphine.**

Give hypodermic doses of 1-60th grain **atropine** until the pupils dilate. This treatment seeming to fail, **chloral** in 10-grain doses, every quarter of an hour, has been recommended.

In certain cases **strychnine** has been used in hypodermic doses of 1-12th of a grain.

Stimulants and **artificial respiration** will probably be necessary in some cases.

CAMPHOR.

Use **stomach-pump** or **tube,** or empty the stomach by emetics.

Hypodermic injections of **brandy,** inhalations of **ether,** the alternate hot and cold **douche,** warmth to the extremities by hot blankets, &c., seem to be the best methods of treatment.

CANTHARIDES—CANTHARIDINE.

Use **stomach-pump** or **tube,** if the mucous membrane of the throat is not inflamed; or administer hypodermic dose of **apomorphine.** or, give emetics— **sulphate of zinc, mustard,** or **ipecacuanha.**

Allay pain with **morphine.** Give plenty of **water** and **demulcent drinks.**

CHLORAL.

Use **stomach-pump** or **tube,** and, when the stomach is emptied, introduce by the same means **warm coffee,** or give a hypodermic injection of **apomorphine,** or administer emetics of **sulphate of zinc,** or **mustard,** or **ipecacuanha.**

An **enema of coffee** will be useful.

Keep the limbs warm.

Administer hypodermically 2 or 3 drops of the solution of **strychnine** at intervals of from fifteen to twenty minutes.

Rouse the patient by various means, such as shouting, shaking, flapping the skin with a wet towel, &c.

Inhalations of **amyl nitrite** are recommended.

Artificial respiration may be necessary.

CHLORATE OF POTASH.

Use the same treatment as for **nitrate of potash** (*which see*, p. 632).

CHLORIDE OF ZINC.—See ZINC.

CHLOROFORM—(*Inhaled*).

Give plenty of **fresh air,** pull the tongue forward, and commence at once **artificial respiration.** If the heart has stopped, strike the chest two or three times very hard, over the region of the heart; this has been found occasionally to restore its beat. Apply the **battery,** but with a weak current only; one pole may be placed on the larynx, the other at the pit of the stomach.

Inhalations of **nitrite of amyl** are useful. The hot and cold **douche** may also be used.

CHLOROFORM—(*Swallowed*).

Empty the stomach by **pump** or **tube,** or by emetics, such as 5 drops of the hypodermic solution of **apomorphine** or **sulphate of zinc** or **mustard.**

Give an enema of **hot coffee.**

Administer large draughts of **water,** which may advantageously contain a little **sodic carbonate** in solution.

Attempt to rouse the patient. **Nitrite of amyl** inhalations, and, if necessary, **artificial respiration** may be used.

CHROMATE OF POTASH.—See CHROMIUM.

CHROMIC ACID.—See CHROMIUM.

CHROMIUM—BICHROMATE OF POTASH—CHROMATE OF POTASH—CHROMIC ACID.

Empty the stomach by **pump** or **tube**; administer a subcutaneous injection of **apomorphine,** or give **sulphate of zinc, mustard,** or **ipecacuanha** as emetics. Follow up by administering, suspended in water, calcined magnesia, or carbonate of magnesia, or chalk.

Demulcent drinks, such as **barley-water,** &c.

COCCULUS INDICUS. See PICROTOXIN.

COLCHICUM—MEADOW SAFFRON—COLCHICUM WINE, TINCTURE, &C.

Use **stomach-pump** or **tube,** or empty the stomach by emetics, such as **sulphate of zinc,** or **mustard,** or **ipecacuanha ;** or, better than all, give a hypodermic injection of 4 or 5 drops of the solution of **apomorphine.**

Give **tannin** or **gallic** acid in half-drachm doses, or strong tea or coffee.

Allay the pain in the bowels and purging by small doses of **opium** or **morphine.**

Keep the extremities warm, apply hot fomentations to the abdomen; **stimulants** may be used, give plenty of **water** and **demulcent drinks.**

COLOCYNTH.

Treatment on the same lines as that of COLCHICUM.

CONIUM—HEMLOCK.

Empty the **stomach** by the **pump** or **tube,** or give a hypodermic injection of 4 or 5 drops of the solution of **apomorphine,** or emetics of **sulphate of zinc** or **mustard.**

Keep up the temperature of the body by hot wraps.

Administer, as a drink, strong **tea, tannin, gallic acids,** or any harmless vegetable decoction containing tannin.

Stimulants may be administered.

If necessary, use **artificial respiration.**

COPPER—SALTS OF.

Empty stomach by **pump** or **tube,** and either inject by the same means or administer **white of egg** in solution in water ; if no white of eggs can be had, substitute milk ; give plenty of **water** and **emollient drinks.**

Pain may be allayed by **opium** or **morphine.**

CORROSIVE SUBLIMATE—PERCHLORIDE OF MERCURY—NITRATE OF MERCURY.

Empty the stomach by the **tube** or **pump,** and wash the organ out with plenty of white of egg, dissolved in water or milk. If the stomach-pump is not at hand, then give emetics, such as the solution of **apomorphine,** hypodermically, in from 4 to 5-drop doses, or a **zinc sulphate** emetic, or **mustard,** or **ipecacuanha**. Probably violent vomiting is already present, then stomach-tube or emetics are unnecessary; but, in any case, give plenty of albuminous fluids, such as **white of egg** in water or **milk.** If neither of these is at hand, chop any **fresh meat** up as finely as can be done in a short space of time, diffuse in water, and administer. Follow up with **demulcent drinks,** such as **barley-water, flour** and **water,** &c.

Pain may be allayed with a little **opium** or **morphine.**

Stimulants are admissible, if necessary.

CROTON OIL.

Empty stomach by means of **tube** or **pump,** or give emetics of **mustard** or **sulphate of zinc,** or administer hypodermic injection of **apomorphine.**

Give 10 drops of **laudanum** every twenty minutes or half-hour, until the pain and purging are somewhat abated, or else inject subcutaneously small doses of **morphine** at intervals.

Give plenty of **demulcent drinks.**

2 or 3 drops of **essence of camphor** in milk are useful.

Stimulants, such as **brandy, ammonia,** or **chloric ether,** are admissible.

CYTISINE.—See LABURNUM.

CURARINE—WOORARI—URARI.

The poison is of course introduced by a wound; if any is likely to be still in the wound apply a **ligature, suck the wound,** and then wash it with a slightly alkaline solution of **potassic permanganate.**

Keep up the **respiration artificially,** give plenty of **water** and a dose of spirits of nitre, apply warmth to the loins. By these means the poison will be readily separated by the urine; and, if the patient can only be kept alive by artificial respiration for a little time, he may recover, for elimination is very rapid.

CYANIDE OF POTASSIUM.—See PRUSSIC ACID.

DIGITALIS GROUP OF HEART POISONS, *including,* besides the DIGITALINS, ANTIARIN, APOCYNIN, NERIIN, OLEANDRIN, EVONYMIN, THEVETIN, SCILLAIN, STROPHANTIN and ERYTHROPHLEIN.

Empty the stomach by the **tube** or **pump,** or administer a subcutaneous dose (4 drops) of **apomorphine,** or give a tablespoonful of **mustard** in water or **sulphate of zinc.**

Follow up with strong **tea,** or half-a-drachm of **tannin** or **gallic acid** in aqueous solution.

A very small dose of **aconitine nitrate** in solution (say 1-200th of a grain) may be injected subcutaneously and the effect watched; if in a little time it seems to do good, repeat the dose. On no account let the patient rise from the recumbent posture, or he may faint to death.

Stimulants in small doses may be given frequently by the mouth, or, if there is vomiting, by the bowel.

ERGOT.

Use stomach-**pump** or **tube,** or empty the stomach by a **mustard** or **sulphate** of **zinc emetic,** or give a subcutaneous injection of **apomorphine.**

Give a purgative, such as a drop of **croton oil,** and assist its action by plenty of warm drinks.

Tannin and **gallic acid** have also been recommended, but are probably of but little use.

After the bowels have well acted, and the stomach has been emptied, give small doses of **opium** at intervals.

Dr. Murrell recommends 1-50th of a grain of **nitro-glycerine** every fifteen minutes.

The recumbent position is necessary, and the circulation should be maintained by warmth, and, if necessary, by friction.

ERYTHROPHLEIN.—See DIGITALIS.

ETHER.—The same treatment as with CHLOROFORM.

EVONYMIN.—See DIGITALIS.

FUNGI.—See MUSHROOMS.

GELSEMININE.

If seen soon after taking the dose, use the **stomach-pump** or **tube,** or give a tablespoonful of **mustard.**

Administer a small dose of **atropine** subcutaneously, or give by the mouth tincture of **belladonna** in 20-drop doses.

Stimulants are admissible.

If necessary, use **artificial respiration.**

Rouse the patient by the hot and cold **douches.**

HEMLOCK.—See CONIINE—CONIUM.

HENBANE—HYOSCYAMINE—The same treatment as for ATROPINE.

HYDROCHLORIC ACID.—See ACIDS MINERAL.

HYDROCYANIC ACID.—See PRUSSIC ACID.

HYOSCYAMINE.—The same treatment as for ATROPINE.

IODINE.

Empty the stomach by **pump** or **tube,** or administer emetics, such as the hypodermic solution of **apomorphine,** or give by the mouth **mustard** or **sulphate of zinc.**

Give plenty of **starch** diffused in warm water, or in the form of a dilute paste; or give any **farinaceous substance** whatever, such as **arrowroot, boiled rice,** or **flour,** or thin **gruel.**

Inhalations of **amyl nitrite** have been recommended.

Pain may be relieved by **morphine** or **opium.**

JABORANDI.—Treatment the same as PILOCARPINE.

LABURNUM SEEDS.—CYTISINE.

Empty stomach by **tube** or **pump,** and wash it out with **tea** or **coffee,** or give (as an emetic) a hypodermic dose of **apomorphine,** or (by the mouth) **mustard** or **zinc sulphate**; follow up this treatment by an enema, or a brisk **purgative.**

Stimulants may be administered; the patient may be roused by the hot or cold **douche.**

LAUDANUM.—See MORPHINE.

LAUREL WATER.—See PRUSSIC ACID.

LEAD—SALTS OF.

Empty stomach by **pump** or **tube,** or administer subcutaneously a dose of **apomorphine,** 4 to 5 drops; or give by the **mouth a sulphate of zinc or mustard** emetic. Follow up with half a drachm of **dilute sulphuric acid,** or half an ounce of **magnesic or sodic sulphate.**

Milk and **albuminous fluids** may be given.

Allay pain with **opium** or **morphine.** Treat colic with hot fomentations.

MEADOW SAFFRON.—SEE COLCHICUM.

MERCURY—SALTS OF.—See CORROSIVE SUBLIMATE.

MONKSHOOD.—See ACONITE.

MORPHINE—OPIUM—*Laudanum and preparations in which the* OPIUM ALKALOIDS *predominate.*

If taken by the mouth, empty the stomach, but, if taken by hypodermic injection, this would be useless. The stomach in opium-poisoning is best relieved by the **pump** or **tube,** and should then be well washed out with hot **coffee,** leaving in the organ a pint or more. If the stomach-pump or tube is not at hand, a large subcutaneous dose of **apomorphine** (say 10 minims) may be given, or **mustard** or **zinc sulphate,** but there may be difficulty in obtaining vomiting from any emetic.

Attempt to rouse the patient by the **battery,** if at hand ; by flips with a towel, and by shaking. In all books will be found the usual direction that you are to keep walking the patient about ; but this treatment is questionable, and likely to favour the toxic action of morphine on the heart.

Ammonia may be applied to the nostrils.

Hot **coffee** may also be introduced into the bowels by an enema apparatus, or by a simple tube.

The alternate **cold and hot douche** to the head is good, but the body should be kept warm with hot wraps.

Small subcutaneous doses of **atropine** (say 1-20th of a grain) may be administered, repeating the dose every twenty minutes, and watching the effect.

If necessary, apply **artificial respiration.**

Inhalations of **nitrite of amyl** have been used.

MUSCARINE.—See MUSHROOMS.

MUSHROOMS—MUSCARINE—POISONOUS FUNGI GENERALLY.

Empty stomach by **stomach-pump** or **tube ;** or give a subcutaneous dose of **apomophine**, or administer by the mouth, either **mustard** or **zinc sulphate.**

Inject as soon as possible a subcutaneous dose of 2 to 4 drops of the solution of **atropine ;** or, after the stomach has been emptied, give tincture of **belladonna** every half-hour in from 20 to 30-min. doses.

It is equally important to remove the remains of the fungi from the intestines, and for this purpose it is well to give a dose of **castor oil,** and to use an **enema.**

Stimulants may be given. The body should be kept warm.

NERIIN.—See DIGITALIS.

NICOTINE—TOBACCO.

Unless the stomach has been already emptied by vomiting, use **stomach-pump** or **tube,** or give an emetic of **mustard** and plenty of water.

Inject subcutaneously a small dose of **strychnine** (say about 1-25th of a grain of the nitrate), or give half-a-drachm of tincture of **nux vomica.**

Stimulants, such as **brandy, chloric ether,** &c., may be given.

Keep the body warm, but the **cold douche** may be applied to the head.

Tannin and vegetable infusions containing **tannin** may also be given, but it is questionable if they are of much use, unless any remnants remain in the stomach.

Keep the patient lying down for fear of fatal syncope.

NITRE—NITRATE OF POTASH.

Empty the stomach immediately by the **pump** or **tube,** or give a subcutaneous dose of **apomorphine** (from 2 to 3 drops), or administer by the mouth a tablespoonful of **mustard,** or a scruple of **sulphate of zinc.**

Dilute the poison, and attempt to wash it out of the system by giving plenty of **water,** or **mucilaginous drinks.**

Apply hot fomentations to the loins, and keep the patient as warm as possible.

Stimulants that are likely to increase the kidney congestion are to be avoided.

Inhalations of **nitrite of amyl** have been recommended.

NITRIC ACID—See ACIDS MINERAL.

NITRO-BENZENE.

Empty the stomach at once by the **stomach-pump** or **tube** and wash the organ out with plenty of warm water, to which advantageously a little spirit may be added ; or give emetics, such as **zinc sulphate** or **mustard.**

Administer stimulants, either by the stomach-tube, as an enema, or by subcutaneous injection.

Keep up the respiration artificially, if necessary, and maintain the heart's action by application of weak, interrupted shocks to the chest-wall, by means of the **battery.**

Rouse the patient by the **douche.**

Atropine subcutaneously has been recommended.

NITROUS OXIDE GAS.

The treatment is the same essentially as for chloroform (*which see*).

Inhalations of **oxygen** may do good, but oxygen is very rarely at hand.

NUX VOMICA.—See STRYCHNINE.

OLEANDRIN.—See DIGITALIS.

OPIUM.—See MORPHINE.

OXALIC ACID—BINOXALATE OF POTASH—SODIC OXALATE.

Unless the patient has already vomited freely, empty the stomach at once by emetics of **zinc sulphate** or **mustard**; or the stomach-**pump** or **tube** may, in most cases, be used. If the acid has been taken, neutralise by **chalk lime water**, or better, by **saccharated lime water**; but on no account neutralise by carbonate of soda or any alkali, for the alkaline oxalates are extremely poisonous.

Assist elimination by the kidneys by giving plenty of **water**; apply hot fomentations to the loins.

An enema may be given, if necessary, to empty the bowels well.

PHOSPHOROUS.

Empty the stomach by **tube** or **pump**, and, at the same time, wash the organ out with water to which has been added a drachm of **French turpentine**, or give emetics. The best emetic for phosphorous is said to be **sulphate of copper**, 4 or 5 grains dissolved in water, and given every ten minutes until vomiting is produced.

In default of sulphate of copper, then **sulphate of zinc** or **mustard.**

Give half-drachm doses of **turpentine,** floating on water or on mucilage, every half-hour. Inhalations of turpentine vapour, much diluted, are also of service. The American and German turpentines are said to be of no avail. Probably, the turpentine will freely purge the patient; but, if not, the bowels should be opened by a suitable purgative, such, for instance, as **magnesic sulphate.**

PHYSOSTIGMINE.—See CALABAR BEAN.

PICROTOXIN—COCCULUS INDICUS.

Use stomach-**pump** or **tube,** or empty stomach by usual emetics —*e.g.*, **mustard, zinc sulphate**, or **apomorphine,** subcutaneously.

Chloral in doses of from 10 to 20 grains, may be given every half-hour to allay or prevent tetanus, the effects being, of course, watched. For the same purpose **bromide of potassium** has been recommended. In severe cases, it may be combined with chloral, 1 drachm of the bromide with 20 grains of chloral.

PILOCARPINE.

The best treatment is a subcutaneous dose of **atropine** (say 1-60th of a grain), or tincture of **belladonna** by the mouth in 29 minim doses, to be repeated every twenty minutes until the pupils dilate.

POTASH.—See ALKALIES.

PRUSSIC ACID.

Use stomach-**pump** or **tube**, or, if not at hand, an emetic of **mustard** or **sulphate of zinc.**

If the breathing has stopped, try **artificial respiration** and weak shocks to the heart.

1-60th of a grain of **atropine** subcutaneously is recommended to assist the heart's action.

A **brandy enema** may be given, or brandy injected under the skin.

The body must be kept warm, but the cold **douche** may be advantageously applied to the head.

SALTS OF SORREL.—See OXALIC ACID

SAVIN.

If the patient has not already emptied the stomach by repeated vomiting, and the throat is not inflamed, use the stomach-**pump** or **tube**, and wash the organ out with water, or give any one of the usual emetics—such as **mustard, sulphate of zinc**, or **impecacuanha.**

If the bowels have not acted well, give a dose of **castor oil**; allay pain with small doses of morphine.

SCILLAIN.—See DIGITALIS.

SNAKES—BITE OF.

Suck the wound, and apply an alkaline solution of **permanganate of potash.**

In severe cases of cobra poisoning and other extremely venomous snakes—death threatening, the only likely means of saving life would be bleeding at one arm and **transfusing** blood by the other.

Ammonia may be given by the mouth, and also smelt.

In cobra poisoning and venoms which kill mainly through the respiration, the breathing must be kept up artificially; and, should there be signs of the heart failing, weak, interrupted **galvanic** shocks may be applied to the walls of the chest.

Lacerda's plan of injecting permanganate of potash under the skin, is not alone useless but mischievous, for it takes up time which might be more valuably employed.

SODA CAUSTIC.—See ALKALIES.

SOLANINE—SOLANUOM DULCAMARA—BITTER SWEET—WOODY NIGHTSHADE.—The same treatment as for ATROPINE (*which see*).

STRAMONIUM.—The same treatment as for ATROPINE.

STROPHANTIN.—See DIGITALIS.

STRYCHNINE—BRUCINE—NUX VOMICA.

Empty the stomach as quickly as possible by an emetic of **mustard,** or **zinc sulphate,** or by a hypodermic solution of **apomorphine** (4 drops).

The stomach-**pump** or **tube** inadmissible ; for, if tetanus is present, it cannot be applied ; or, if absent, it is likely to excite a spasm.

Place patient at once under **chloroform** or **ether.** and keep up a gentle narcosis for several hours, if necessary.

Darken the room, stifle all noise ; if in a town, and opportunity permit, have straw or peat placed at once before the house to deaden noise.

If the spasms threaten the respiration, **artificial respiration** is absolutely necessary ; and, to facilitate this, it would be justifiable, in a dangerous case, to perform **tracheotomy,** of course under chloroform.

Chloral may be given in place of chloroform, but the latter is best ; the dose of chloral should be, at least, half-a-drachm, and if no effect is produced in half-an-hour, then doses of 20 grains should be given at intervals of a quarter of an hour.

If neither chloroform nor chloral is at hand, the **juice** from a recently-smoked pipe may be diffused in a little water and a few drops injected subcutaneously, and the effect watched. If there is a marked improvement the treatment may be persevered in.

Bromide of potassium in combination with chloral has been recommended.

Nitrite of amyl inhalations are said to be of use.

Curarine, in a subcutaneous dose of one-third of a grain, is antagonistic so far that it paralyses the voluntary muscles.

SULPHURIC ACID.—See ACIDS, MINERAL.

TARTAR EMETIC.—See ANTIMONY.

TARTARIC ACID.—The same treatment as for OXALIC ACID (*which see*).

THEVETIN.—See DIGITALIS.

TOBACCO.—See NICOTINE.

TURPENTINE.

Empty stomach by **tube** or **pump**, or administer the usual emetics, such as **mustard**, or **sulphate of zinc**, or **ipecacuanha**, or give hypodermically 3 or 4 drops of the solution of apomorphine.

If purging is not already present, empty the bowel by enema; give plenty of water and demulcent drinks to aid elimination by kidneys.

Apply hot fomentations to the loins.

Allay pain with **opium** or **morphine**.

VERATRINE.

Empty the stomach by the **tube** or **pump**, or give any one of the usual emetics—such as **mustard**, or **zinc sulphate**, or **ipecacuanha**.

Keep the patient lying down.

Stimulants may be administered.

An enema of **hot coffee** has been recommended.

Keep the body warm with wraps, hot blankets, &c.

WHITE PRECIPITATE.—The same treatment as for CORROSIVE SUBLIMATE.

WASPS, BEES, HORNETS—STING OF.

An **onion** immediately applied to the part stung is a favourite popular remedy; but **ammonia** is better.

Extract the sting, if it remains in the wound.

Give **stimulants**, if necessary.

ZINC.

The only salt likely to cause poisonous symptoms is the chloride, which is used in the arts, and is the active principle of Burnett's disinfecting fluid,

Stomach-**pump** or **tube** inadmissible. Give plenty of **water**, in which **carbonate of soda** is dissolved; or, if that is not at hand, **carbonate of potash**.

Eggs and **milk** should also be given.

Solutions of **tannin**, strong **tea**, and the like, also, to some extent, neutralise the poison.

The pain in the abdomen is to be allayed in the usual way—by hot fomentations and small frequent doses of **morphine** or **opium**.

DOMESTIC READY REMEDIES FOR POISONING.

Large households, more especially those in which no one possesses any special medical knowledge, would do well to furnish an ANTIDOTE CUPBOARD, for use in cases of emergency. This cupboard may contain:—

(1.) The *Multiple Antidote,* which consists of saturated solution of sulphate of iron 100 parts, water 800, magnesia 88, animal charcoal 44 parts. It is best to have the animal charcoal and magnesia mixed together in the dry state and kept in a well-corked bottle; when required for use, the saturated solution of sulphate of iron is mixed with eight times its bulk of water, and the mixture of charcoal and magnesia added with constant stirring. The multiple antidote may be given in wineglassful doses, frequently repeated, in poisoning by arsenic, zinc, opium, digitalis, mercury, or strychnine; it is of no use in phosphorous poisoning, or in poisoning by the caustic alkalies or antimony.

(2.) *Calcined Magnesia,* for use in poisoning by acids.

(3.) *French Turpentine,* for poisoning by phosphorus.

(4.) Powdered ipecacuanha in a well-corked bottle; the bottle containing a small pill-box which is cut down, so that when full it contains 30 grains—the proper dose as an emetic. A similar small supply of sulphate of zinc may also be provided.

(5.) A tin of mustard.

(6.) A bottle of vinegar.

If, then, provided with such a supply, any member is known to have taken poison, and yet the precise poison is not known, give a **sulphate of zinc** or **ipecacuanha emetic,** and follow it up by the **multiple antidote,** which is in itself not poisonous.

If PHOSPHORUS has been taken, then give the **French turpentine** as directed under phosphorus (p. 634).

If ACIDS, neutralise by the **calcined magnesia**—(see Acids—mineral, p. 623).

If ALKALIES, neutralise with **vinegar**—(see Alkalies, p. 624).

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